TECH BULLETIN 9401:

INTRODUCTION TO CABLE TV SYSTEMS

-PART TWO of TWO-

-ABOUT TECH BULLETIN-

Tech Bulletin is produced and distributed by technology author and researcher Robert B. Cooper five (5) times per year. **Tech Bulletin** selects a single 'topic' for discussion and devotes one or more issues to the selected topic such that readers/users may utilise the material for reference and business planning.

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TECH BULLETIN 9401(T)-
CABLE TELEVISION IN NEW ZEALAND
(Part Two of Two)

Cable television (CATV) origins date at least from pre World War Two in both Germany and the UK. Prior to the war BBC tested television extensively and realised the erratic nature of VHF 'line of sight' transmission. Where hills and distance intervened for direct reception to individual receiver locations, the British created a system to be known as rediffusion; substituting wire (twisted pair at the time; coaxial cable was largely unknown) to provide a 'connection' between a single receiving site and multiple TV receivers. The early rediffusion systems are only genetically related to today's CATV however as vision was sent through one set of twisted pair, sound through another and both at 'baseband,' not at radio frequencies. The German's took a more directly related to CATV approach utilising a parallel (90 ohm) cable (twinlead) to wire complete buildings and in some instances blocks of buildings for RF distribution of the early TV test transmitter programming. Neither system returned at the cessation of war time hostilities although rediffusion did appear briefly in a few British colonies (Barbados, Hong Kong) in the late 1940s and early 1950s. We still find the word rediffusion in our lexicon today; New Zealand's 1962 Copyright Law, in trying to cope with the possible development of cable TV here, refers to the system by that word and legally rediffusion still is the descriptive term for cable.

Cable TV as we have known it from the 1950s onward was an American and Canadian creation; coaxial (first 50 ohm, shortly and thereafter 75 ohm) cable originating at a master (antenna located) receiving facility called the 'headend' in the trade and radiating outward from there to as many homes/locations as the cable could reach with reasonable quality pictures and sound.

Coaxial cable systems dominated the technology until quite recently. Today, a brand new cable system stands a 50-50 chance of being built initially using either fibre optic or coaxial cable hardware. Fibre offers the builder essentially unlimited bandwidth expansion and the opportunity to send information in both directions (i.e., two-way) with greater ease than coaxial cable. However, it does this by being more expensive initially than coaxial cable and by requiring still quite sophisticated 'transition devices' going into and coming out of each home connected to the system. A transition device converts the lightwave energy carried in fibre optics to standard radio frequency energy that allows the TV receiver/VCR or other interfacing equipment to make some sense of the fibre delivered data.

The switch to fibre optics was largely tied to two factors that entered the Cable TV industry during the late 1980s:

1) The need for greater bandwidth.

2) The need for two-way signalling.

While it might seem unlikely that any rational human being could ever make proper use of, or have a need for, 100 separate channels of television, cable TV in Europe and North America passed that level of simultaneous programme delivery several years ago. And transmitting 100 channels through a coaxial cable network pushes at the outer boundaries of a state-of-the-art (analogue) coaxial network. Cable's primary reason for needing more 'spectrum space,' by the way, is movies; cinemas delivered into the home 'on demand' or on 'near demand.'

The Cinema Connection

Cable systems exist to extract money from customers. They did this initially by merely delivering regular terrestrial television to a quality and (channel) quantity which the individual homeowners could not create with rooftop aerials. When in the mid 1970s alternate (cable 'only') programming began to be delivered via satellite, cable operators were forced to upgrade the bandwidth (spectrum capacity) of their systems to accommodate the new satellite delivered services. In regions of the world where broadcasting and satellite delivery are far more advanced than in New Zealand, it is the combination of terrestrial channels (often as many as 25 available) and satellite delivered channels (a mind-blowing 200+ available in both Europe and North America) which pushed the 100-channel limits of traditional coaxial cable to the breaking point.

To extract more money from consumers a change in business philosophy was suggested. Cable as an industry decided to invade the turf of another group: the video rental stores. Within the video store industry, a number of marketing trends become self evident. For example, more than 35% of video store rental income in any measured month comes from the rental of typically fewer than 10 films. If you expand the market to 50% of all income, 21 films on average make up that portion of the monthly revenue.

The cable industry created a scenario where they might take the top-20 films for any individual month and assign each movie its own channel. Next they created hardware that made it possible for individual homes to 'sign in' and 'sign out' from individual movies at will. When they 'sign in' they pay a movie rental fee, not dissimilar to the video store fee. When they sign out, the charges stop. And it is all handled automatically with microprocessor equipped in-home subscriber order boxes.

Which brings us to the need for two-way communication capability. If every subscriber home has a microprocessor controlled 'box' and that box logs in and out their tuning in of specialised movie channels, to properly bill (charge) people these boxes must communicate their logged data back to the cable company and its master computer(s). Early schemes used the telephone line for this purpose; in the dead of night the cable company computer called the telephone line number of the subscriber and interrogated the microprocessor box atop the TV receiver. Any 'logged viewing' of movies, for which there was a charge, went back to the cable company where it was added to the customer's monthly statement.

But the telephone connection requires special hardware and an association with the telephone company. The cable operators realised their own coaxial cable network could accomplish the same chore if its 'one-way' design was modified to a 'two-way' design. While some cable operators retain their telephone line connection for polling of customer 'boxes' today, many began conversion of their coaxial plants to two-way to allow all of the communications required to be within the cable plant proper.

Lest you believe this is a relatively minor portion of the international cable 'mentality,' try this number on for size. Of all US homes connected today to cable TV (64.7% of all US homes or 57,200,000), 37.9% (21,678,000) can be 'computer addressed.' And that number is projected to grow by some 4,000,000 homes in 1994 alone. Ultimately, perhaps by 2000, virtually every cable home in America will have two-way capability.

So two-way cable adds the second element to the increased bandwidth problem. While the cable itself may be two-way capable, spectrum specific portions of it must be assigned to each direction of 'message travel;' one portion for cable-to-home, one portion for home-to-cable company. Traditionally, the region between 5 and 35 MHz within the secure transmission spectrum of the coaxial cable network is assigned to the 'return' (home to cable) link and from someplace around 48/55 MHz upwards to the limits of the cable electronics (i.e., 330 MHz in the case of Paraparaumu's first design; 750 MHz in more modern systems) for the cable to home portion.

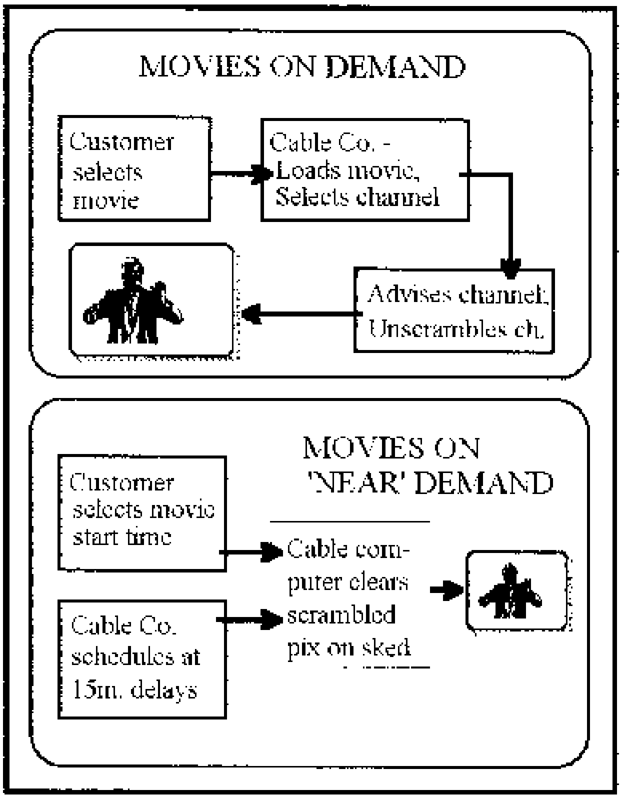
And then 'Movies On Demand' hit.

Cinema Connection-Two

By assigning a specific movie to a specific channel (for as long as the movie draws revenue) the cable service turns into a shopping mall cinema. Individual movies were assigned (well promoted) 'start times' and consumers now had the option of staying at home and selecting which recent release picture they wished to watch. The costs run in the NZ$7 per film range. Twenty movies - 20 channels. And twenty channels x 7 MHz bandwidth per channel equalled a new demand for 140 megahertz of spectrum space. Now the available spectrum in the cable systems was pushed even more severely. The next plateau would send the already bulging cable spectrums through the roof.

A creative cable marketing man decided to take just the top five movies and rather than assign them to a single channel each, assign each movie to as many as 8 channels each. He started each movie at 15 minute intervals so viewers who wanted to watch a specific film could select their start time without waiting for a half-over movie to finish and recycle. They called this 'Movies On Near Demand' and it was a big hit. But if a 2 hour movie requires 8 channels (i.e., starting it in 15 minute intervals; 120 minutes divided by 15 is 8), then five movies require 8 channels each ... or 40 channels. The available spectrum was quickly exceeded.

In Paraparaumu, Kiwi Cable with its limited 330 MHz bandwidth decided to take the experiment one step further. They assigned all available extra channels (approximately 26) to movies. But they scheduled no specific movies. Rather they circulated to their approximately 300 subscribers a list of nearly 1,000 films they had available on VHS tape. And they invited the subscribers to order '*any movie, at any time*.' When the order was received, the customer was assigned one of the 26 available 'movie channels,' a tape placed in a VHS player and the Kiwi Cable computer sent a command to the set-top TV converter at that one specific customer's home. That command told the customer's converter to unscramble the encoded picture and sound. No other cable customer decoders received that message; to them, that channel remained 'scrambled' and unusable.


MOVIES ON DEMAND
Customer selects movie
Cable Co. - Loads movie, Selects channel
Advises channel; Unscrambles ch.
MOVIES ON 'NEAR' DEMAND
Customer selects movie start time
Cable Co. schedules at 15m. delays
Cable computer clears scrambled pix on sked

Alas, after 26 homes had ordered a movie, all of the available channels were filled. From a cash flow perspective, 26 homes paying $4 each for a two hour film works out to $52 per hour. Could this additional gross revenue possibly pay for the massive investment in equipment and tapes required to provide this service? The answer was no, even before the labour required to make such a system work was included.

Kiwi Cable was overwhelmed with the response, but reaches too few people to build on volume. What it needed to make this a profitable service was several hundred homes all ordering movies at the same time. To do this, Kiwi Cable needed far more channels (i.e., bandwidth).

Total 'Movies On Demand' (*any movie you want, at any time*) rather than specific movies on 'near-demand' is consumer friendly but perhaps technically impractical at this point in time. Still, Kiwi Cable shows no outward sign of revising their project in the near term future. Rather, they are making a modest change in the Paraparaumu cable plant to increase the bandwidth from 330 MHz to 550 MHz. This adds 31 new channels for movies and gives a maximum total of 57. At the same time they are increasing the number of homes they serve by expanding the cable system into new areas hoping to reach 600 subscribers by mid-fall. Obviously if 300 homes overloaded 26 channels (i.e., created more orders at peak times than there were channels to service the orders), 600 homes could have the ability to put a serious dent in 57 channels. A cable system serving 10,000 homes, for example, might require (by extrapolation) 860 movie-on-demand channels in the same peak-time periods. This could be a no-win (i.e., you never get ahead and perhaps never even become profitable) scenario. Kiwi Cable's "experiment" (and it is just that) runs counter to the direction other (US and European) cable operators are headed. There could be such a thing as being 'too consumer friendly' in this business.

Meanwhile, back in the US and Europe, the 'Movies On Near Demand' portion of cable TV has spread like wildfire. Kiwi Cable, here, reports the average home is ordering between 5 and 6 movies per month; this effectively doubles the cable company's gross receipts from its regular cable income stream. Similar results are reported in cities such as San Diego where homes free to select movies (starting at 15 minute intervals) are doing so on average 4.8 times per month; each.

The new MOND (Movies on Near Demand) industry has now expanded into the direct satellite broadcasts that now reach some 4,000,000 US and 20,000,000 European homes. By assigning specific satellite transponders to movies, starting movies in 15 minute offsets, and allowing home satellite dish owners to dial up a toll free number to order the movie of their choice at the start time of their choice, the satellite systems send their descrambling authorisations directly into the home via the satellite link itself. In the new (April this year start) DirecTv service using 460cm dishes in North America, MOND will collectively consume more than 50% of the available satellite programming bandwidth.

The movie industry likes this; alot. Never totally comfortable with the video store distributors of their product (i.e., always suspicious of the accounting that store owners turn in monthly with their payment cheques), the movie rights owners prefer to deal with the cable or satellite business people whom they seem to doubt less. And the movie people make more money this way. Video stores typically retain 70% of the rental fees on movies they handle, arguing they provide all of the distribution, warehouse space and must physically handle the tapes. The cable and satellite companies require only a handful of tapes per film title, and the movie companies retain close to 50% of the rental fee for each film.

The cable and/or satellite viewer finds the services tempting because they can shop and select from their homes avoiding a special trip or a specific stop at a video store to pick up a film; plus the second trip to return the film. And they never have to worry about rewinding the tape!

Clearly, if movies are going to drive cable and satellite programming to the next consumer acceptance level, and typically double the revenue of the cable and satellite system operators, there must be a downside in this.

Bandwidth, the original hurdle facing the cable operator (as well as the satellite operator), is that downside.

Digital Or Fibre Optics?

By mid year 1993 there were two possible answers to increasing bandwidth. Both had their pluses and minuses. It was even possible to design a system that used both of this options.

Fibre optic cable, in place of coaxial cable, offers greatly increased bandwidths. Individual fibres have the technical capacity to equal a piece of coaxial cable. Multiple fibres, bundled together, can increase the bandwidth ability by as many fibres as you care to bundle into a common 'jacket.' (Yes, you could also bundle coaxial cables and in fact in a few locations twin cable systems have been built to provide increased coaxial cable capacity.) The downside of fibre is it costs more to activate a fibre plant than a coaxial plant (today), largely because of the fibre to RF transition devices required at each home. There is one more downside; running fibre directly into the home still presents several serious problems so most fibre systems take the fibre to the street just outside of the home, convert there from light waves to RF, and then go the last 30 or so metres into the home in coaxial cable.

Digital compression of video is the second alternative. As readers of CTD (Coop's Technology Digest) for our August 1993 issue understand, world-wide the present day system of transmitting television programming using an 'analogue' system is in its final decade. More than 50% of all new TV receivers and VCRs will by 2000 be in digital video form, and in most regions of the world the TV broadcasting networks will have begun transmitting simultaneous digital format television services parallel to the old fashioned analogue format service. And by 2010, even the most backward countries of the world will have abandoned analogue TV.

What this has to do with cable TV service is everything. One of the reasons why digital is replacing analogue is that digital is far more spectrum efficient. It takes a 7 MHz wide 'channel' today to transmit a television programme. With digital format, that same 7 MHz 'channel' will easily handle 4 totally separate TV programmes as a minimum; as many as 20 separate TV programmes when certain adjustments are made in the original to-be-transmitted product.

-KIWI CABLE TODAY-

Forward bandwidth: 280 MHz, 40 analogue channel equivalents
Reverse bandwidth: 30 MHz, 4+ channels
Delivery: Analogue 7 MHz per channel
Maximum MOD Customers: 26 at a time

-PHASE TWO / KIWI CABLE-

Forward bandwidth: 500 MHz, 71 analogue channel equivalents
Reverse bandwidth: 30 MHz, 4+ channels
Delivery: Analogue 7 MHz per channel
Maximum MOD Customers: 57 at a time

-PHASE THREE / KIWI CABLE-

Forward Bandwidth: 500 MHz, 71 analogue channel equivalents / 1140 digital channel equivalents
Reverse bandwidth: 30 MHz, 4+ analogue / 100 digital channel equivalents
Delivery: Optional analogue or digital
Maximum MOD customers: 1100+ at a time

It turns out that movies are easily 'adjusted' such that 20 separate movies will fit into a single 7 MHz wide TV channel spectrum.

Now let's relook at Kiwi Cable's situation. With 26 present day (7 MHz wide) analogue channels, they can send 26 movies at one time. If they make the conversion to digital, each of these 26 (7 MHz wide) 'channels' becomes capable of transmitting 20 separate movies; a total then of 520 movies! Now take their newer 550 MHz bandwidth plant rebuild which provides them with 57 (7 MHz wide) analogue channels for movies. That's 57 channels times 20 movies each or 1140 separate movies all being transmitted simultaneously. Thus with 550 MHz bandwidth, Kiwi Cable is prepared to service between 13,000 and 15,000 separate homes and provide each one with a reasonable opportunity to have '*any movie at any time*' they wish; for a fee.

But in a city as large as Christchurch, Wellington, or Auckland, a business built around '*any movie at any time*' becomes very cumbersome when your cable plant reaches 100,000-plus homes. If the Paraparaumu experience to date is meaningful, a system with 100,000 subscribing homes could require as many as 9,000 separate programming channels to satisfy peak hour demands on a Friday or Saturday night. And the logistics of having tape playback machines, not to speak of a film library of sufficient size to back up 9,000 tape playback machines, is frightening.

This suggests to many in the cable industry that MOD is a concept not to be realised except in relatively small communities for the foreseeable future. MOND, the almost-as-good alternative is the direction the rest of the world is headed.

It is worth a short paragraph to note that the very idea of thousands of VHS playback machines and the physically expansive library of VHS tapes required for this service is somewhat dated. Today, if you begin a such a service (as Kiwi Cable has done), this is the only option you have. However, within three years (or less) the VHS players will be replaced with CD-I (video on CD disc) packages and the bulky VHS tapes will replace with carousel loading, computer controlled disc storage facilities; '*any disc to any player at any time*.' The present day Kiwi Cable '1,000 tape library,' occupying a floor to ceiling wall some 7 metres in length, will shrink to a pair of 500 disc CD-I carousel loading mechanisms that will occupy less than a metre of wall space. And best of all, the discs will be ordered up on a computer keyboard that simultaneously selects and assigns a vacant TV programming channel to the specific disc while automatically transmitting a descrambling message to the consumer's specific set top decoder. The movie will literally start without being touched by human hands. Even the billing record will be automatically recorded in the single software programme that supports the system.

The Subscriber Interface

None of these technology wonders will amount to very much unless the subscriber is comfortable with the system. To accomplish this, the cable system must deliver a product at a price which the consumer considers 'friendly.' And, the cable system must satisfy the consumer's order with a minimum of effort on the part of the consumer.

All of this leads us to the interface between the consumer's (analogue style for the immediate future) television set and the cable company. Modern day television sets have varying degrees of channel capability. In the US, 'cable ready' TV sets have tuners built in which are capable of scrolling through as many as 181 separate (analogue) TV channels. Very few of the TV sets delivered to New Zealand for distribution go much beyond 30 channel 'memory' tuning. The cable industry sorted out this problem more than two decades ago by providing, typically at their expense or for a nominal small (NZ$5 per month) fee per month, a set top cable 'converter.' The word converter was originally used to mean a box that had a wider frequency range channel selector (i.e., tuner) than the average TV set. The cable comes into the home and plugs into the cable converter. The cable converter outputs to the TV set on a standard TV channel; such as Kiwi channel 2 or 3. The cable subscriber (using a remote control supplied with the cable converter) changes or selects channels through the cable converter. The TV set, for as long as it is plugged into the cable via the cable converter, never moves off of the channel that matches the output of the cable converter.

When cable began transmitting a wider range of channels which included some channels that the cable viewers were offered as 'optional extras,' the cable companies routinely scrambled (encrypted) the optional-pay channels. This created a new demand for the set top cable

-DEVELOPMENT OF SET TOP 'CONVERTERS/TRANSLATORS'-

1
Tuned 'mid-band' only (108-174 MHz); added 11 new channels
When cable went to 20+ channels (1970-1974)

2
Tuned 54-270 MHz; 36 channels total; some elementary descramble
Introduction of multiple satellite programmes('76+)

3
Tuned 54-330 MHz; 46 channels; hardwire descramble standard
Ability to hand programme descramblers added

4
Tuned 54-450 MHz; 66 channels; electronic addressing added
Individual descramblers respond to address/descramble instructions

5
Tuned 54-550 MHz; 82 channels; view logging added for billing
Individual units log premium viewing; 'dump' to cable billing computer

6
Will tune 54-750 MHz; add digital/analogue D/A, computer jacks
Will allow MOND, 2-way dialogue with cable computer, interactive

converter. Now it had to receive and convert channels that were outside the TV set's tuning ability to a common output channel, and, it also had to descramble selected channels. At first the decrambling was done exterior to the cable converter; then it was built into the cable converter and the box became (a) a cable converter, and, (b) a cable descrambler.

Then there appeared MOND where individual subscribers were making programming decisions which required near-real-time decoding instructions. Now the descramblers had to have an 'electronic address' which would allow any single decoder to unscramble any single channel when it was instructed to do so by a command transmitted through the cable system. Life was becoming more complicated for the set top box.

This is the level of technology currently in use at Kiwi Cable; each subscriber has an 'addressable set top converter' and the cable operator sends commands through the cable telling which decoders are authorised to receive each of the channels on the system. This becomes '*any channel at any location at any time*' technology.

But, the 'response loop' between the cable customer and the cable operator was still outside of the cable system; i.e., the cable customer picked up the telephone, dialled the cable company, and through a one on one human to human interface made arrangements for a specific programme at a specific time. This might work out for 300 cable subscribers; for 100,000 cable subscribers it is out of the question.

Enter the next generation of cable set top box; it had to do everything the last one did plus it also required the ability to form the 'order loop' connection. Ideally, the customer would take the remote control which he or she possibly now wore on a chain around their neck and enter the proper sequence of commands telling the set top converter which movie they wished, and, at what time. Now the set top box must take this hand held remote command and turn it into an order which it automatically transmits to the cable company.

Some cable companies in the US accomplish this loop through a phone modem and jack on the converter box. Once the set top box understands the remote initiated command, it automatically dials up the cable company and connects to a microprocessor at the cable office. The microprocessor in the set top box 'talks' with the cable company's master processor and the order is entered. While the cable customer has gone to the kitchen to get a cold one from the frig, electronics does the rest. When the cable customer returns at the MOND start time, his set top converter has received an instruction through the cable system as to which channel to be tuned to and there on the screen the movie begins on time; all without human interface at the cable company.

Kiwi Cable would love this to be their system today. They fantasise of the day when CD-I players and carousel loading mechanisms coupled with a two-way interactive (that word had to come out eventually) cable system will allow their customers to order a movie or special programme from their hand held remote. And for that programme to automatically place itself on a computer-selected available channel while the customer's 'intelligent set top converter' rechannels itself to the selected channel. Neat, clean, automatic. By 1998 or 1999 Kiwi Cable could be at that plateau. But not today.

The technology to do all of this exists today. It is, in fact, in use today but on a relatively small scale since the set top converter (a word to be superseded by the new to us word 'translator') world is just now gearing up for mass production of these 'interactive' set top boxes. During 1994 approximately 500,000 of these magic new, smart, boxes will find their way into the first truly 'interactive TV homes.'

It is important to also realise that these 'translators' are very much expanded in purpose and function. The latest versions:

a) Determine whether the programme selected by the cable viewer is in analogue, or, digital format. If it is analogue, it then must determine whether the programme is scrambled or unscrambled. And if scrambled, it must ask the customer "*Do you wish it unscrambled?*" A "*yes*" from the customer records a 'billing instruction' within the 'translator' which will at a later hour be transmitted back to the cable company master accounting department computer where it will be entered on that customer's billing record. If the customer does not wish it unscrambled, he receives no reception on that channel. If the programme is in digital form, the sequence diverts to the digital to analogue 'translator' portion of the box after the "*Do you want it?*" sequence is repeated.

b) If the programme selected is available on a MOND schedule, the customer is asked new on-screen questions; "*what time do you wish this service?*" for example. Through the hand held remote the customer 'communicates' with the 'translator' and the translator then immediately opens up a 'loop line' to the cable company computer which sets in motion the approval and scheduling of that programme to that customer at the appropriate selected time. And the cable company accounting computer records the 'event' so the order appears on the cable customer's next monthly bill. Finally the cable company encoding command computer sends an addressed command to the set top 'translator' telling it that it is OK for it to descramble a specified channel at a specified time.

All of this happens without the cable customer being involved after he began the sequence of events with his hand held remote commands.

As you might suspect, the once 'simple design' cable converter has become quite a feat of new technology engineering. And the price per box has increased dramatically. Whereas cable converters of basic design can still be purchased in factory sealed cartons for under NZ$90 each today, the newest 'translator' boxes are closer to NZ$700 each. In simple terms, this means that when a new home signs up for cable, the cable operator basically trots out $700 in hardware to place in the customer's home as he connects up the home. That his $700 box is 'safe' there, and, that he will realise sufficient income from that box to pay for it and the extensive cable plant and head end that supports it is a new level worry for the cable system planner.

All of this can happen with a consumer owning a traditional, present-day analogue format television set. Why? Because the cable system decision to transmit some or all of its channels in digital format never reaches the TV set without first going through a set top (cable provided) translator. And if the channel/ programme selected is in digital rather than analogue format, the set top 'translator' does the translation with a D to A (digital to analogue) converter. Thus the transmission format is transparent to the viewer at all times.

Interactive Television

A TV viewer with two or three channels of Kiwi television would find much of this, to here, quite incomprehensible. That there could be another step in the chain is "Twilight Zone" material.

Late in 1993, the computer industry took official notice of what was happening in the cable industry. Cable companies, with very large transmission bandwidths, were now into the two-way loop business. It occurred to several people at about the same time that a cable system was a perfect tool to allow two or more computers to connect in real time.

From the outset of the computer revolution technology has been driven by 'speed;' how fast could information be transferred from one terminal to another? As long as the two computer terminals were located such that a piece of hard wire could connect the two directly, the transfer speed was determined largely by the individual computer processing speeds.

-FUTURE DEMANDS/TRANSLATORS-

Frequency selection and conversion to a TV-set compatible (i.f.) is the basic set-top unit function; and the least complicated. Basic 'boxes' that continue to perform this function remain available, largely because of Taiwanese manufacturers selling to non-North American cable systems.

Frequency selection based upon flexible digital channelling ('any frequency at any time') followed by digital to analogue conversion is the new 'basic function' of General Instruments/GI, Scientific Atlanta and other 1994 era boxes. To that add almost-basic individual unit addressability (allowing individual units to be turned on and off, channel by channel, by computer addressing), and two-way capable communication between a set-top and the cable company computers.

Now add interfacing to external PC disc and hard drives, wide bandwidth (several megabyte) interactive (real time) connection to data bases delivered by the cable and the ability to perform telephone functions as well; the 'translator' of the 90s.

When computers began to communicate over distances, a new problem arose. The interconnecting 'loop', almost always provided by the telephone company, was 'bandwidth limited' to speeds far slower than the computer's ability. To resolve this the telephone companies created new higher quality loops, largely built around their fibre optic lines and offered computer to computer interfacing, over distance, at greater bandwidth/speed. But at a sizeable price to the computer linkers.

Computer system designers have created a number of bandwidth enhanced programmes using information compression techniques (not dissimilar to the compressed digital video that is so radically reshaping the TV broadcasting industry). But, there is no real substitute for real bandwidth. Cable offered real bandwidth.

If cable could increase the 'speed' at which computers could 'talk,' perhaps the cable bandwidth could also be used for other services? Serious investigation from the likes of Sega, 3DO and other leaders in the home computer/software fields followed. The answers, still being tabulated, were quite exciting.

Through a cable interface, Sega will now be able to 'load' full game software from the cable company headquarters to individual homes. It is movies on demand, only replace movies with 'Sega Gameware' (on demand). No longer would Sega have to place games on discs, pack them for shipment, argue for retail store display space, and worry about store accounting. Now with cable as a partner Sega (and dozens of software firms like them) would sell through the cable delivery system directly to the home loading each home directly from a master 'hard drive.'

Alas, this was one more requirement for the magic 'translator box' atop of the TV set. Now it must have a 'jack' to interconnect to the home PC such that the Sega software would load directly onto a consumer's disc or hard drive.

Now, late in 1993, the entire 'interactive digital TV' world was seemingly growing beyond even the ability of the highly involved 'trade press' to keep up.

It was only a small step from asking that the 'translator' include the ability to relay Sega games to the PC to asking it to be 'a PC terminal' itself. This was the point where the manufacturers of set top converters / translators asked for a temporary hiatus to new configurations. The demands being created were pushing the once simple box into a new world that was more computer than translator or converter.

There is only so much new technology that the world can assimilate and place into hardware and practice at one time. That level would seem to have been reached at the point where the 'translator' moved into an ordering mechanism.

Sega, undaunted, is therefore pioneering a satellite delivered game delivery channel of its own. If it can't convince the cable operators to act as an interface and sales agent for it today, it will create its own satellite channel and sell directly to the consumers; bypassing the cable company processing desks completely. As long as the translator manufacturers had agreed to provide an 'output jack' to the PC, Sega was able to create a channel that would allow it to distribute games and programming on its own through the cable system delivery system.

But that is not the 'interactive TV' that keeps making headlines in the newspaper and 2 minute reports on TV newscasts. It is merely the tip of an iceberg that will continue being defined and redefined throughout the next decade.

The system of the future will utilise all of the capabilities of fibre optic transmission lines, compression of data and high speed modems to facilitate '*any bandwidth at any time to any place* (ABATAP).' And your grandchildren will wonder how you managed to live without it.

The Real World - 1994

Into this almost surrealistic world of the future we must plug in our present New Zealand. In the best case, 8 channels of terrestrial one-way television largely originated (live or on tape) from places other than New Zealand, and fed into the home using a spectrum hungry analogue format that will within twenty years be only a dim memory for collectors of artefacts. In the worst case today, two channels of the same.

New Zealand Telecom would like to be the vehicle to transport us from the dingy analogue world of the present to the free-flowing-data digital world of the future. New Zealand Telecom, like all telephone utilities world-wide, is as mystified by this onrush of technology as the rest of us. And although we tend to perceive Telecom as a giant among corporations, even they cannot afford the luxury of upgrading to fibre optic unlimited bandwidth capabilities each and every home in New Zealand. Not without additional sources of revenue.

One of the primary present concerns in the United States is not how to accomplish '*any bandwidth at any time to any place*,' but rather how will (or simply will?) customers use this capacity once it is in place? Extensive consumer testing is underway there now; some as large as 100,000 homes (Omaha, Nebraska). The size and scope of these tests makes a mockery of our New Lynn and Pakuranga Telecom tests of fibre optics. The speed at which these test systems are being created is in dramatic contrast to the year long period Telecom in New Zealand has spent laying fibre optic cable in front of a mere 600 homes in two Auckland suburbs. That Telecom, significantly owned by two American telephone giants, can gain any useful information from such a minuscule test involving 600 Auckland homes is seriously questioned.

Contrary to the Auckland experiment, US and British tests involve providing several hundred TV programme channels and dozens of interactive computer based information services to each test home. To date Telecom has managed only nine TV channels and no information services. Their promise of more TV services, possibly MOND, perhaps some information services this year does not bode well for any meaningful tests of consumer appetites for fibre optic based high speed data. That the Auckland tests will provide any information of any value to Telecom planners is not a frivolous concern.

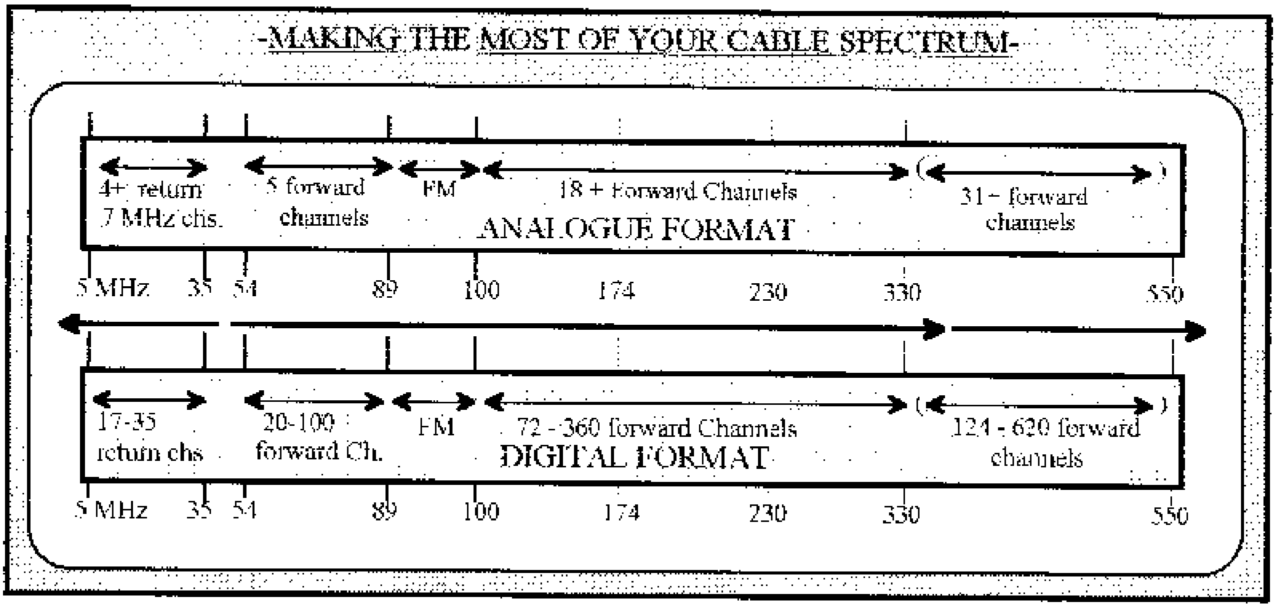
Yet data on the consumer appetite for services beyond mere transmission of new television entertainment services is what interactive television is really all about. American tests now underway are linking fibre optic connected cable homes to computer network services with information transfer rates in excess of 500,000 baud; fifty times faster than typical telephone interconnects. In a year's time, and several hundred thousand test homes later, a body of practical results will have evolved. It is of interest to observe that in the United States firms such as CompuServe, Sega, and Time Warner are literally standing in line to 'test' their interactive software products on test bed cable systems; whereas in New Zealand Telecom has not announced a single software test partner. In terms of meaningful, future-oriented consumer 'testing' the Kiwi Cable system experiments with Movies On Demand are far more advanced than anything Telecom has initiated to date.

Telecom's New Lynn/Pakuranga test system is fibre optic distribution, coaxial cable into the home. To accomplish this the fibre optic lightwave 'signals' must be 'translated' to radio frequency signals before plugging into the existing analogue TV sets. The hardware to do this inside the home barely exists at the laboratory level so Telecom is forced (along with the 100,000 home test systems in the likes of Omaha) to make this translation outside the home; typically in kerbside boxes that serve up to 20 homes each. It is probable that such kerbside 'translating' from lightwaves to RF is an interim technology to be replaced by lightwaves into the home in perhaps a decade. The fear that this is true acts as a spending brake on Telecom and other telephone firms worried about making substantial plant investments today that will be outdated before their time.

However, until there is fibre into the home proper, directly to the then-interactive computer/TV set, the entire system will be evolutionary. You cannot order the ultimate system today; you must go there in measured steps.

Coaxial Cable Today

In a country with only one functional cable TV system, the business opportunities for CATV are unlimited. Everything about New Zealand's present state of television broadcasting points at the need for hundreds of privately owned cable TV systems. Every element for a successful business is in place, with one possible exception; some lingering



doubts about the Copyright Law of 1962 (Tech Bulletin 9305: page 16).

As discussed in Tech Bulletin for December (TB9305: Cable TV, Part One) basic cable is a reception extension service. A community with a low grade of TV reception, or an inadequate level of TV programming, will support a system that clears up the present reception and adds new channels in the process. Throughout the world, from China to Sweden, New Zealand to Canada an estimated 120,000,000 homes are now served by cable that performs just this function.

At a meeting held in Wellington November 9th at the New Zealand On Air headquarters, TV3 executives announced "*We will spend no more TV3 money to extend TV3 service.*" The television network was appearing before NZOA seeking a commitment for more than $12,000,000 in NOZA funds to 'complete TV3 coverage.' By TV3 calculations, 7% of New Zealanders (245,000) today remain outside of TV3 transmitter coverage. They consider the balance of New Zealand now unserved 'not economical to serve' and TV3 coverage is thus frozen in time at its present level until somebody else comes up with the funds required to complete coverage.

The issue is germane to any community which today does not have TV3 coverage. That TV3 will receive $12,000,000 in NZOA funds to complete their coverage is a major issue today; most predict NZOA will fund no more than 10% of that requirement. This says, simply, that those towns and areas where TV3 does not reach are likely to still be without service five or ten years down the road; unless cable TV comes to the rescue.

This creates a primary need for cable TV in those TV3-unserved communities. Where traditional cable TV antenna engineering (see Tech Bulletin 9302, 9303 and 9305) can bring in TV3 to unserved communities, the cable entrepreneur has a golden opportunity to establish a business for which there is demonstrated need.

But ... which type of 'cable' system?

Recall that Kiwi Cable's 330 MHz cable 'plant' is today capable of providing as many as 26 movie-on-demand channels plus their regular programme fare. In fact, a 330 MHz 'bandwidth' plant is actually 280 MHz wide; starting at around 50 MHz and extending upwards to 330 MHz for the forward (cable to home) delivery mode. In the case of Kiwi Cable, the lower portion of the spectrum (5 to 35 MHz) is reserved for a two-way function.

In a 280 MHz forward direction bandwidth cable plant there is room for 40 analogue (7

MHz wide) TV channels. Or, if we think in terms of the future digital transmissions, 40 seven MHz 'channels' times 20 movies per channel: 800 separate programming channels. Seemingly any New Zealand community with up to 12,500 potential cable homes would get along quite nicely - today and tomorrow - with that many 'programme channel options.' Kiwi Cable's upgrade, now underway, to 550 MHz cable electronics will produce 500 MHz of actual forward direction bandwidth; sufficient for 71 analogue TV programmes or 1,428 separate digital programme channels.

Kiwi Cable's upgrading to 550 MHz is primarily an interim step taken because the firm needs more analogue bandwidth; today. You will recall their movies-on-demand service is 100% sold out at peak hours now, with 26 available movie channels. If this were 1996 rather than 1994, and Kiwi Cable could install 1996-available digital transmission equipment while equipping subscribers with the new 'translator' set top boxes, its present 330 MHz electronic plant would be quite adequate for the movies-on-demand peak time loads.

There is a message here for any new-to-cable entrepreneur. It is unlikely you will provide a service similar to movies-on-demand before 1996 if you are starting today with the basic cable system planning. It is also likely you will not need more than 10-12 analogue TV channels for the transmission of cable programming before 1996. Therefore, most of the TV sets you are likely to encounter in the home can already tune the first 10-12 analogue channels you will deliver. With some careful channel planning, you can do a start-up service providing the basic 'extended range' services of cable over the next 24 months without investing in very many (if any) set top cable converters. When you are ready to expand your service with either analogue or digital offerings, above the initial 10 to 12 channels, then you can approach the decision of which transmission system and which set top converters/translators will suit your mid to long term needs. This is not a decision that needs to be made at the outset.

330 vs. 550 MHz?

When we speak of a cable TV 'plant', this refers to the network of cable, passive devices (signal splitters, customer tap-offs, et al), and 'actives' (cable amplifiers) plus the mechanical hardware required to install the equipment on existing utility poles. In TB9305 we quoted an average installed cost in our example system of $7,335 per kilometre for the cable plant (page 9: TB9305).

Within the cable plant subset of a cable system (i.e., separate from the headend portion), the 'active' or amplifying equipment is a major cost item. A typical CATV amplifier is designed around special design 'gain blocks' (chip amplifiers) created specifically for this service. These gain blocks are housed in a weatherproof (typically cast aluminium) housing that splits open like a clam shell to reveal two sets of circuit boards inside. One set of boards is for RF amplification and signal control; the second set (usually appearing in the half-shell opposite the RF portion) is the power supply and logic circuitry.

Those who study component parts know you can, for a few dollars, purchase a broad band 'gain chip' offering 15-20 dB of RF amplification over a frequency range such as 10 to 1,000 MHz. While such chips are seldom capable of handling the high output levels or number of separate carriers found in a cable system amplifier, they are none the less in the same family of devices.

There are six important measurement criteria for cable plant amplifiers:

1) Bandwidth - how much spectrum does it cover?

2) Gain - how much gain is available (controls allow adjustment of the total gain over a range)?

3) Output capability - before the amplifier generates objectionable distortion (which can degrade the picture quality), what is the maximum output level?

4) Noise figure - a lower amplifier noise figure contributes to higher quality pictures (signal to noise measurement ratios) and directly affects the number of amplifiers that can be 'cascaded' (strung out in a line).

5) Slope/tilt - because the coaxial cable has increasing loss (attenuation) with increasing frequency, an amplifier operating over a wide frequency spectrum must somehow compensate for this 'tilt.'

6) Intermod - All amplifiers cause a measureable amount of distortion in the amplifying process. This distortion produces 'beats' or harmonics which accumulates with each additional amplifier.

Solid-state cable TV line amplifiers first appeared in 1961. The original 'single-ended' designs eliminated the tedious and troublesome tube style amplifiers that required their own, individual sources of mains AC for operation, and, frequent retubing. From the first 'single ended' amplifiers to today's push-pull, power doubling and other designs there has been steady progress in amplifier characteristics. Amplifiers designed and built after approximately 1975 have most if not all of the basic desirable characteristics found in today's circuits with the possible exception of 'bandwidth;' few amplifiers went beyond 330 MHz in 1975, few today do not go to 550 MHz.

Playing With Cable Layouts

Planning a cable TV system requires two knowns:

1) The location of the headend (cable origination point), and,

2) An accurate street map of the community to be cabled, showing house/commercial building locations and possible routes (such as existing power company pole lines) which the cable TV lines could follow.

By knowing the headend location, you can calculate your RF signal voltage losses through cable to any point in town. By knowing the possible routes which the cable could follow, you have a way to plan the RF signal path through the community.

-PHYSICAL CABLE FORMATS-

Aluminium jacketed (sheathed) cable, shown above in two formats with 1/2 of outer sheath cut away, uses either foam dielectric (right) or air dielectric (left). Air provides a superior transmission medium, higher velocity of propagation (cable on left 93%, cable on right 82%), lower losses per increment of length. Decision involves initial cost of cable versus electronics: higher losses require more amplifiers.

Basics first.

The transmission medium is coaxial cable. This is 75 ohm cable (the standard of the industry) and it is formed by taking a copper or copper clad centre conductor and suspending it rather precisely inside of a solid aluminium (jacket) shield. The copper centre conductor is held centred within the aluminium 'tube' with some type of insulating material; foam (plastic), concentric spacers or a spiral of plastic. The aluminium shield, while totally weather tight and a seal against moisture ingress, may also be coated with a drawn-under-pressure (black) plastic jacket which provides additional protection; especially against corrosives in the air (aluminium will oxidise) or nicks and abrasions if the cable is accidentally whacked or bumped during installation or maintenance. If the cable is to be placed underground, a 'flooding compound' is injected under the outer plastic jacket, between it and the aluminium 'shield', to 'ooze' in and 'fill' any accidental nicks in the outer jacket from sharp rocks or other in-ground obstructions.

Like all coaxial cable:

1) Attenuation (loss per increment of length) is a function of frequency

2) Larger diameter cable (i.e., physically larger) exhibits lower loss than (most) smaller diameter cable(s) at any given frequency.

3) The impedance match for all parts of the system (including the cable itself) is very important. Mismatch (75 ohm cable connected to a 50 ohm device, for example) creates standing waves on the cable leading to ghosts and degraded pictures. For this reason all connectors used with the cable have been carefully designed for 75 ohms. Most devices within the cable plant have cable fittings included and those that require connectors specify specially designed 75 ohm connectors created for use with the solid aluminium sheathed cable.

Cable Losses vs. Cable Distance

The basic parameter of planning a cable system is to make some assumption concerning the amount of signal level to be delivered to the household (cable connected) TV set. World standards range between 0 dBmV (1,000 microvolts across 75 ohms) and +12 dBmV (3,980 microvolts) to the TV set at 75 ohms. TV sets with 75 ohm 'antenna' inputs are directly connected (either from the cable itself or through a converter) while 300 ohm receivers have a 75-300 ohm matching transformer installed. Measurements are always made at 75 ohms and cable grade signal level meters (SLMs) allow you to individually measure signal levels for each TV channel.

If the desired level to the TV set is between 0 and +12 dBmV, you know how much signal must be 'tapped' out of the nearest feeder/distribution line to go into the home. We'll return to this subject.

The two most common 'sizes' of cable now in use for CATV plants are '500', and '750' (pronounced seven fifty). '500' is actually shorthand for 1/2 inch (.500 of an inch) diameter cable; a measurement made with bare aluminium cable. '750' is actually 3/4 inch diameter; both diameters being approximately .1 inch larger in the real world when a plastic jacket has been added.

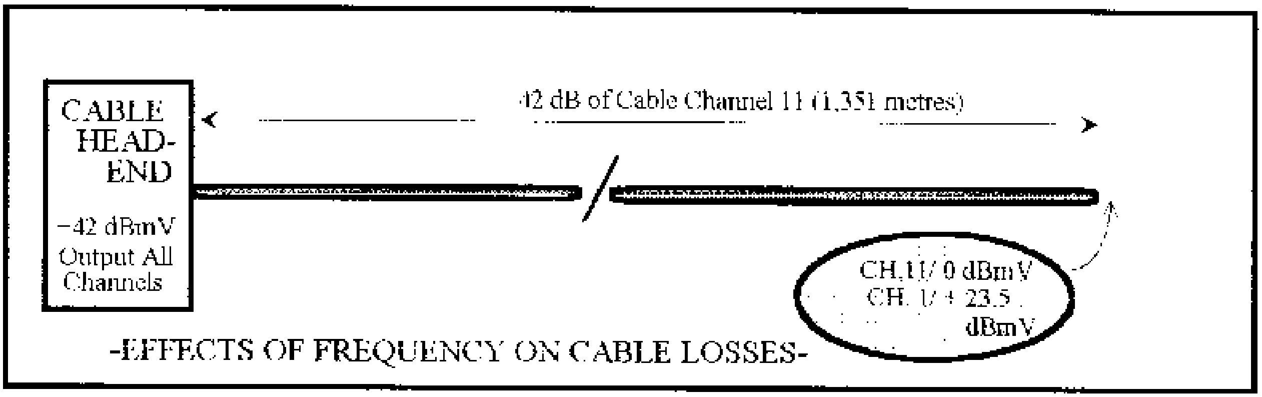
-TYPICAL CABLE ATTENUATION-

FREQ	RG59	RG6	500	750
5 MHz	2.82	2.00	0.46	0.33
35 MHz	5.22	4.24	1.29	0.92
54 MHz	5.64	4.43	1.35	0.96
89 MHz	6.68	5.26	1.63	1.15
174 MHz	9.23	7.25	2.33	1.63
230 MHz	10.9	8.57	2.79	1.94
330 MHz	13.89	10.92	3.61	2.51
550 MHz	19.42	15.28	5.08	3.54

dB losses per 100 metres of cable at 20 degrees C.

Not surprisingly, 500 cable has somewhat more loss per incremental length than 750. Even larger cables (1 inch for example) are available but they are difficult to handle (install) without specialised equipment. Both 500 and 750 can be 'man handled' by an experienced crew for either overhead (utility pole) or underground installations. Cables typically arrive on wooden spools in lengths from 1500 to 2,200 feet (458 to 672 metres). Two men can just lift and move such a roll of cable and it will be moved several times between arrival and placement.

Typical losses are shown here for both cables. Note that we also show losses for RG-59/U and RG-6/U cables. Neither is used in the plant proper but either of the two are commonly chosen to connect individual homes to the cable lines and in this use they are known as '(house) drop cables.'


CABLE HEAD-END
+42 dBmV Output All Channels
42 dB of Cable Channel 11 (1,351 metres)
CH.11/ 0 dBmV
CH. 1/ + 23.5 dBmV

-EFFECTS OF FREQUENCY ON CABLE LOSSES-

In planning a cable plant, you begin by knowing (from equipment specifications) the amount of RF signal voltage available at the headend. As we discussed in Tech Bulletin 9305, the headend receives and processes all of the various programming sources. Each cable channel has its own amplifier, heterodyne signal processor, or modulator. Each of these units has a maximum rated RF output signal level; a number such as +60 dBmV.

The individual outputs of each channel's equipment are mixed together into a single (combined) output; this is how you get all of the channels together on one cable. In that mixing/combining process, passive combiners are used to insure each unit feeds signal voltage only towards the master output, not back into each other. There are signal losses in this combining process, and when you have 12 channels combined, for example, the original +60 dBmV (1 volt at 75 ohms) from each channel's processing equipment will have diminished to around +42 to 46 dBmV.

This combined output of all channels is called the 'trunk input' meaning now we have a complete broadbanded multi-channel TV cable service altogether on one cable. The cable that leads out of the headend, to feed to the cable TV plant, is called the 'master trunk.' This is the point where we begin our cable plant 'loss calculation' for the passive cable attenuation. If the (combined) headend output/trunk input levels are +42 dBmV, for example, that is the level of RF signal voltage with which we begin our cable plant layout calculations.

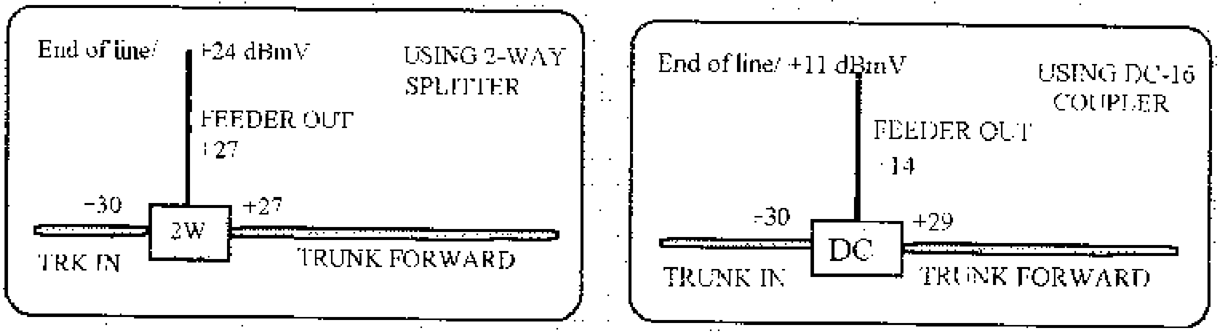
Laying out a cable plant begins with a street map as earlier noted. The street map has been refined to tell you where there are utility poles (assuming you will attach your cables to existing utility poles), and where the potential homes and business subscribers are located. Beginning from the headend with a known 'master trunk' signal voltage (+42 dBmV in our example), you begin to see how much cable you can stretch throughout the community, street by street, before you 'run out of signal voltage.'

Remember that the minimum level to any single home is 0 dBmV. If the output from the headend is +42 dBmV in theory if you had only one home to serve you could send signals through 42 dB of cable (+42 down to 0 dBmV) without re-amplifying the signal. In 500 size cable, that would amount of 4,424feet/1.351 metres of cable if we use the highest frequency channel (11) on our cable as a reference point. We diagram that here.

Note that when we left the headend in the diagram with +42 dBmV of signal at channels 1,2,3 .... and 11, and went through the example 1,351 metres of cable before reaching 0 dBmV at channel 11, we ended up with a 'reverse tilt' to the cable signal levels at the end. Because of the effect of frequency on the cable losses, our channel 1 signals have attenuated only 18.5 dB in the 1,351 metres of cable while our channel 11 signal has attenuated the full 42 dB. We'll return to that point.

In the real world we have more than one home to serve and they are unlikely to be in

-SELECTING BETWEEN LINE SPLITTER AND DIRECTIONAL COUPLER-



such a straight line that you can simply run directly from the headend to the last home without some 'branching.'

One way to serve these 'branch lines' is to place a signal splitter in the line: one input (facing the headend), two (or more) outputs, each for an 'output branch.' Suppose, however, the branch line down a side street needs only go a short distance; say 100 metres? It is wasteful to place a two-way splitter at this point since such a splitter divides the available signal voltage into a pair of equal parts. In this example, you end up with a very high signal level at the end of the short 100 metre branch line and this is wasted signal. The option, and it would be the correct decision here, is to install a device called a 'directional coupler' at this branch point. The directional coupler is designed to take a measured (less than 50%) amount of signal out of the 'master trunk line' for the branch line, leaving the majority of the signal intact to continue down the master trunk.

Trunk lines, then, can be 'split' (two, three or four ways with equal signal voltage going to each output) or they can be 'coupled' with a measured (by design) amount of signal going out the coupled port, the balance remaining for the 'trunk through' port.

Losses or reductions in thru-port signal levels are precisely calculated on paper by the system designer. The designer knows:

a) The signal level available from the headend

b) The attenuation of the cable(s) at each frequency

c) The losses from each line splitter, and each directional coupler

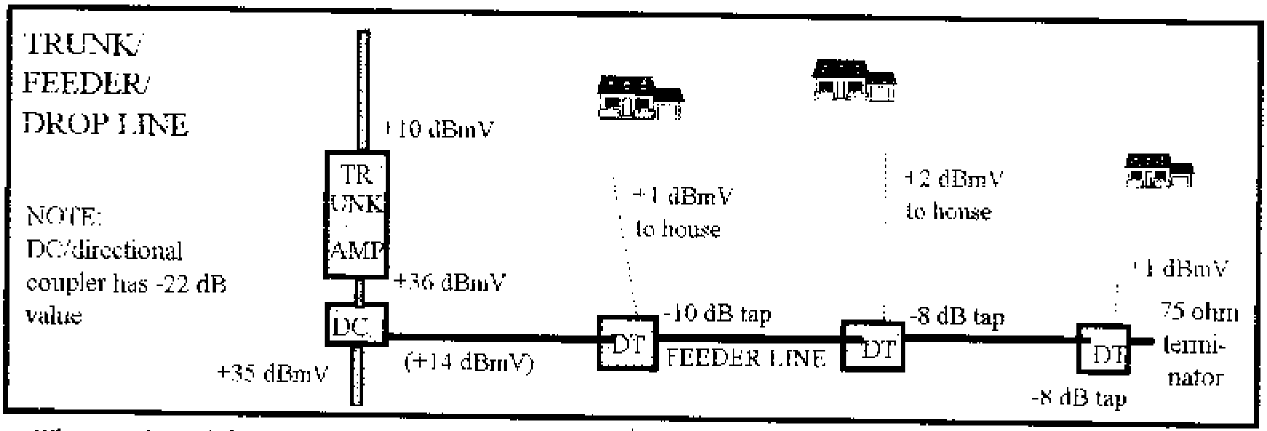
d) Additional losses for each specific passive device inserted into the line.

If the headend has +42 dBmV output, and there is 31 dB of cable loss and 9 dB of split/passive loss in a specific plant plan, the signal level at the end will be 41 minus 31 (+11) minus 9; or +2 dBmV. The technology is so mature that 95 times out of 100 the actual measured levels will be within a fraction of a dB of the calculated levels; unless of course during installation someone installed something improperly (such as installing a coupler 'backwards'). CATV plant planning to CATV plant implementation is a quite precise 'science.'

Trunk vs. Feeder Cables

Except in very small CATV systems (defined as *a system that has no more than 3 plant amplifiers located between any customer and the headend*), the plant is built around two 'levels' of cable. In most systems, 750 cable is selected for the trunk segments while those branch lines that feed signal down streets to homes use 500 cable.

The object is to place the standard signal level (0 to +12 dBmV) into the TV set input terminals for every set on the system. A sub-objective is to make the best use of the available RF signal voltages present on the line; to leave no 'high (RF) voltages' at ends of lines where they are wasted.



The trunk and feeder concept is that a trunk is the master line and under no circumstances do you (ever!) connect a home to the trunk. Of course nobody is connected directly to a feeder cable either; each home has its own miniature 'directional coupler' as an isolation device. This is important since it is possible for a TV set to feed local oscillator or other trash signal(s) back into the cable line. Rather than tying a home directly to your cable, you 'isolate' that home through a directional coupler; another point we shall return to shortly.

So customers are served by feeder lines and the feeder lines are served by trunk lines. The way CATV plant design works best is to create a plan where no home in the system has more than three feeder line amplifiers between it and the trunk. If you can reach to the end of a feeder line, from a trunk line, with one, two or at most three feeder line amplifiers, you can be assured of high quality pictures for the customer. Beyond three feeder line amplifiers the distortion products generated within amplifiers accumulate to levels which begin to paint faintly disturbing 'beat patterns' within the pictures; obviously to be avoided.

So now we know how to go about designing our trunk and feeder system:

a) The trunk is as short as possible, and covers as little territory as possible because it costs money.

b) Working backwards from the ends of the feeder line served streets, you design a system so that no feeder line has more than three feeder line amplifiers on it. This tells you where the trunk line must reach (so the trunk line can 'bridge' into the feeder line at that point).

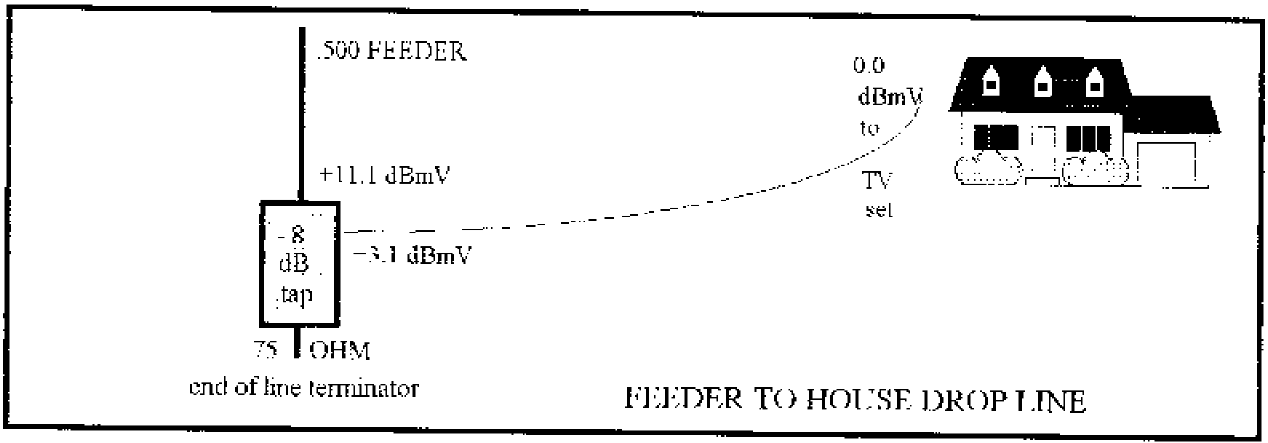
Feeder Line Losses

The feeder line losses are calculated like the trunk line; cable has attenuation, splitters and directional couplers have 'thru loss.' But there is one more element involved; signal level to the home.

Minimum signal level to the TV set (0 dBmV worst case) is calculated at the set; not at the street where the drop cable connects to the feeder line. Between the feeder line and the TV set you have drop cable and that drop cable also has loss. If we assume a 30 metre drop line length with 3.1 dB per 30 metres in RG-6/U drop cable, we can compute the required signal level coming out of the feeder. This is diagrammed here.

Working backwards from the TV set, if 0 dBmV is the minimum TV set input level, and we have 3.1 dB of drop cable between the TV set and the feeder line, then the output from the feeder must be (+ 3.1 dB) – 0.0 dBmV.

But you cannot (never!) connect the home directly to the feeder line; remember the need for 'subscriber isolation.' So a directional coupler goes into/onto the feeder cable and a measured amount of signal level is taken from the feeder and sent down the drop cable. A directional coupler (also known as directional tap or 'DT') always works at a level lower than the actual feeder line level. An 8 dB DT value means the DT signal level going to the



FEEDER TO HOUSE DROP LINE

subscriber is 8 dB lower (i.e., -8 dB) than the feeder line level at that point.

In this example the actual feeder line signal level at the point where the (last) customer plugs in is 0 dBmV + 3.1 dB (the loss in the drop cable) plus 8 dB (the isolation in the DT); or, +11.1 dBmV.

Any level greater than this 11.1 dBmV at the end of the feeder line is wasted signal voltage; signal voltage which you could be using someplace else in the cable plant.

Amplifier Inputs and Outputs

In most situations the output level from the headend will not be adequate to overcome the combined cable and passive losses to reach all homes. To make up for these losses, solid state line amplifiers are installed.

Trunk line amplifiers are built to higher standards than feeder line amplifiers. Unlike feeder line amps where three in a row (i.e., three in 'cascade') is the maximum number recommended, trunk line amps can be cascaded to 'depths' of 30,60 or even 120 with careful planning. 'Depth' means the number of amplifiers after the headend to the last trunk line amp in the system.

Amplifier specifications, you will recall, included noise figure. The input signal level to the trunk amplifier must be strong enough to produce a minimum of 48dB signal to noise ratio; larger numbers (such as 54 dB signal to noise) are desirable.

In the cable TV world, a 75 ohm line terminated with its own impedance (75 ohms) will have a 'noise floor' of around -57 dBmV in a 7 MHz wide bandwidth. This is useful information. If the trunk line amplifier has a specified noise figure of 10 dB, and we wish to have a 54 dB signal to noise ratio at the input to the amplifier, here is how the calculation works:

a) Desired signal plus noise to noise : 54 dB
b) Noise floor: -57 dBmV
c) Amplifier noise figure: 10 dB

The calculation is straight forward. Take the desired signal plus noise to noise and place a + sign in front of it; +54 dB. Now subtract the noise floor (-57 dB) and we have -3 dBmV. Finally, add back the amplifier noise figure (10 dB) and we have -3 plus 10 or +7 dBmV. That (+7 dBmV) is the minimum input signal required to our amplifier to produce 54 dB signal plus noise to noise ratio (for an analogue TV channel).

+7 dBmV then is the lowest trunk line level we dare to feed into a trunk line amplifier. If you calculate your cable losses and passive device losses you will pinpoint an exact point on the cable where +7 dBmV signal level is reached. This will be at the highest channel on the cable since we are concerned that the highest loss cable channel (the highest frequency channel) is 'clean.' All other channels will be better than this because they have less cable attenuation loss (being lower in frequency).

The trunk amplifier choice will offer gain ranges; 22-30 dB gain, 30-36 dB gain, 36-42 dB gain. More gain in the amplifier costs more money. Let's assume for example a trunk amplifier with 30-36 dB of gain.

If the input signal is +7 dBmV, and the gain is as much as 36 dB, then the output level will be +43 (36 + 7) dBmV; maximum.

In the practical design world we never run amplifiers at full output since having a few dB of gain 'in reserve' is simply prudent. The output level of the amplifier is adjusted with a control while using a signal level meter to read the output level (done through a test point port found on the outside of the cast aluminium housing). So on paper, a +7 dBmV input signal to the trunk can be safely calculated to become a +40 dBmV output level signal at the trunk output by using 33 of the amplifier's 36 dB of gain capability.

At each trunk output you begin the cable attenuation/losses plus passive loss calculations all over again, continuing down the cable plant (away from the headend) until you reach a point where the combined losses return you to a +7 dBmV signal level again. This is where the next amplifier is installed and the procedure is repeated.

Feeder Line Amplifiers

The calculation procedure for feeder lines is identical to trunk lines. The subscriber directional taps each have a 'thru loss' factor (from as little as 0.2 dB to as much as 1.4 dB) and this must be added to the feeder line cable attenuation losses and the splitter and other passive losses. Feeder line amplifiers, a standard 'down' from trunks as explained, typically have higher input requirements (such as +20 dBmV) and slightly greater output abilities (such as +46 dBmV). This means their real 'gain' is closer to 25/26 dB than the 36 dB of gain in our example trunk amplifier. The combination of (a) lower amplifier gains, (b) higher attenuation in 500 cable than 750 cable, and (c) contributed thru losses for each subscriber directional tap all adds up to closer feeder line amplifier to amplifier spacing than you have with trunk line amplifiers.

The Tilt Problem

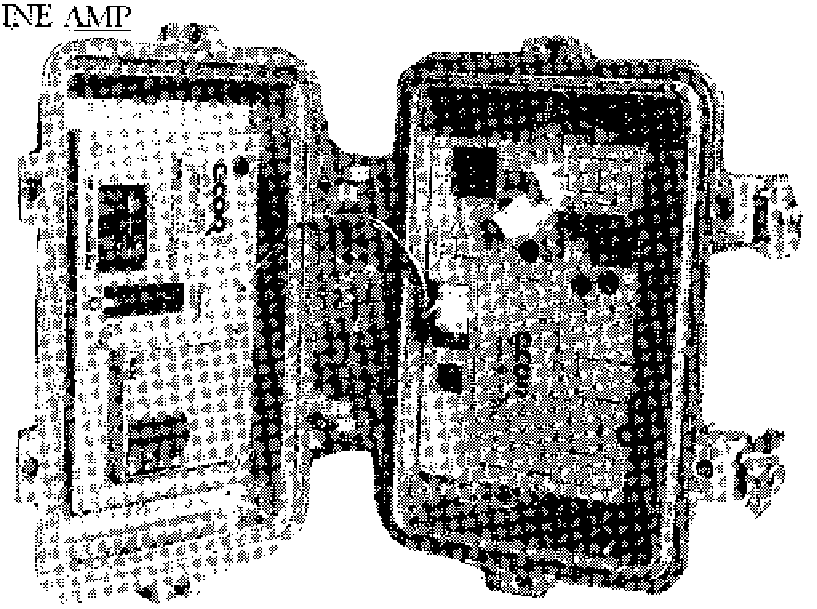
Recall that because cable attenuation is greater at higher frequencies, if we exit the headend with +42 dBmV RF signal voltages on each of our VHF TV channels, we will arrive at a point where the first trunk amplifier must be inserted (i.e., in our example where the highest channel (11) has come down to +7 dBmV) with proportionately greater signal levels at the lower channels.

In our diagrammed simple system where it took 1,351 metres of 500 cable to reach a level of 0 dBmV at channel 11, the channel 1 signal at the same point was +23.5 dBmV.

There are several good reasons why you cannot allow this tilt to continue through the system. First of all, if the input to the first amplifier has a tilt that favours channel 1 by 23.5 dB, and the amplifier contributes 33 more dB of (flat) gain to all signals, now the output level from the first amplifier is still 23.5 dB hotter on channel 1 than on channel 11. But the channel 1 signal is also well above the rated amplifier output capability; by the amount that the input on channel one exceeded the input on channel 11. And by the time we arrive at the second trunk amplifier, we have this tilt times 2; or 47.0 dB. Having very strong low band (channels 1, 2 and 3) signals while having designed-for levels at channel 11 is poor engineering. It will result in amplifier overload at the second amplifier, plus (our fourth reason) very strange looking pictures on feeder lines.

'*Tilt*' is the answer. The ideal situation is for every trunk and feeder line amplifier to have a 'flat input;' or, every channel is at the same level coming into the amplifier. If the inputs are flat (i.e., +7 dBmV for our trunk amps, +20 dBmV in our feeder line amplifier example), the gain block in the amplifier can amplify the entire frequency range (such as 50-330 MHz) also 'flat.' That makes for a happy amplifier with

ANATOMY OF A CABLE LINE AMP



Clamshell enclosure gasket seals under pressure when closed; AC to DC powering left, RF circuits on right.

output of the trunk amplifier. A passive equaliser is like a frequency selective attenuator; in this case it attenuates the amplified output at the low end (channel 1) by some predetermined amount, gradually attenuating each successive higher channel a little less, so that when reaching the top channel (11) there is no attenuation at all.

Equalisers typically plug into the amplifier and the cable operator selects an appropriate value equaliser for each amplifier location. In this way when the amplifier puts out +40 dBmV at channels 1 through 11, the signal is equalised and the actual levels going into the trunk cable on the output side of the amplifier may have channel 1 at +28 dBmV, channel 2 at +29 dBmV, channel 3 at +30 dBmV and so on up to channel 11 which has the full +40 dBmV output.

Between the equalised output and the input to the next trunk amplifier, the cable's own 'slope' or effect-of-frequency on the attenuation levels it all out again and into the next trunk amplifier the input is once again flat; +7 dBmV in our example.

Cable Line Powering

All active cable plant equipment needs powering. The original cable TV tube type amplifiers required connection to a (230v) mains circuit and each had a built-in AC to DC power supply to create the appropriate operating voltages for the tubes.

Solid state amplifiers fortunately operate at lower DC voltages; voltages in the 18-25 volt range for the actual circuits are not uncommon. In most political jurisdictions regulations (i.e. power company standards and safety standards) allow you to duplex an AC operating voltage into the 500 or 750 cable along with the TV signals. In this way the cable plant powers itself from widely spaced mains-connected power supplies.

Why not send DC through the 500 and 750 cable if the amplifiers actually require DC; thereby eliminating an AC to DC conversion in each amplifier? *Electrolysis*. A standard CATV power supply (the item that connects the 230vac mains to the cable plant) is designed to supply around 12 amps of AC current to the CATV plant equipment. It could almost as easily supply 12 amps of DC. But you are dealing here with aluminium, copper, brass and silver (the latter two in the connectors) and with 12 amps of DC current flowing through some of the connections, electrolysis (the creation of white, corrosive powder such as you see on an non-maintained car battery terminal connection)

CATV plant equipment. It could almost as easily supply 12 amps of DC. But you are dealing here with aluminium, copper, brass and silver (the latter two in the connectors) and with 12 amps of DC current flowing through some of the connections, electrolysis (the creation of white, corrosive powder such as you see on an non-maintained car battery terminal connection) is guaranteed. Actually, before this problem was obvious the very first solid state CATV line amplifiers did use DC powering; for about six months time. It has been AC ever since.

Cable power supplies are primarily step-down transformers with a degree of voltage transient protection. The mains voltage at the point of connection (they usually mount directly on the utility pole) is stepped down to either 60 volts ac (the first choice), or 30/35vac. This voltage is 'duplexed' into the coaxial trunk cable and typically flows in both directions on the cable plant from the insertion point. Two factors affect the number and location of cable power supplies:

1) Current consumption: Most trunk amplifiers require around 1/2 amp of current to operate. On this basis alone a 12 amp power supply would power 24 trunk amplifiers. Feeder line amplifiers require less; around .3 amps.

2) IR losses: The copper centre conductor/aluminium jacketed cable has a resistance factor and this resistance causes voltage drop when coupled to the individual amplifier spot-current loads. Most CATV line amplifiers require an after DC conversion regulated voltage of around 20-23 volts to function properly. By starting with a 60vac source, in the cable, the cable system IR losses can be quite substantial before the DC regulated voltage level is reached. By starting at 30/35vac, IR losses appear more quickly.

Each amplifier location, with its .300/.500 amp current consumption, is a 'lump' voltage drop point. Calculation of IR losses, current consumption and required minimum DC operating voltage for line amplifiers is a second, important, pre-plant planning exercise. The cable RF plant system is designed first; then you go back through the plant and calculate current consumption(s) and IR losses, working out where the power supplies must be added to the system.

Because each amplifier has its own AC to DC power conversion unit (each with controls to make on-site adjustments for the actual measured operating voltage available there), it is a relatively simple design parameter to assign one polarity of operating voltage to trunk amplifiers (such as +/positive to trunks) and the opposite polarity (-/minus) to feeder line amplifiers. This results in a full AC cycle consumption (the trunks use the positive half, the feeders use the negative half) and provides the system designer with yet one more parameter, and degree of flexibility, when he is laying out a community system.

System RF Stability

The headend produces a very stable output level to the trunk cable; each channel has automatic output levelling circuits and a variation of +/- 1/2 dB on any channel is considered maximum tolerable.

Once you have laid out a system and have become accustomed to calculating dB losses and gains to the nearest 0.1 dB, you begin to appreciate the sophistication of the system parameters. It would not do for the trunk line RF signal voltages to wander all around, even within a seemingly tolerable +/- 3 dB 'window.'

Variations of +3dB in one section of the plant can multiply by that amount or more as the signal travels further and further into the system. Because each amplifier after the first is dependent upon the constant output level of the amplifier ahead of it for its carefully set gain and output conditions, plant RF signal stability is mandatory.

You might wonder how, if the headend is stable in output and the plant is mechanically secure, variations might occur. The answer is *temperature.*

Coaxial cable suspended in the air is subject to the variations of temperature of the air itself. Coaxial cable losses (i.e., attenuation per increment of length) are specified on charts at a particular ambient air temperature; 22 degrees C for example. When coaxial cable rated at say 1 dB attenuation per 30 metres at 22C becomes subjected to temperatures of 35C the cable losses increase. In 30 metres of cable the additional losses will be small; perhaps 0.05 dB. But if the cable plant has 20,000 metres of cable, those 0.05 dB additional losses every 30 metres become monstrous.

Conversely, when cable is in a cooler ambient temperature, the losses go down. Perhaps to 0.95dB per 30 metres at the specified frequency at 10 degrees C. These seemingly small changes in attenuation must be compensated for or after a thousand plus metres of accumulative cable they are potentially tens of dB in change.

At one earlier stage in cable's development temperature sensors were fitted to trunk amplifiers typically every third or fourth trunk amplifier, and if the temperature went up, the amplifier activated an automatic gain circuit that bumped the gain up just enough to make up for the increased temperature. When the temperature went down, the gain was automatically reduced.

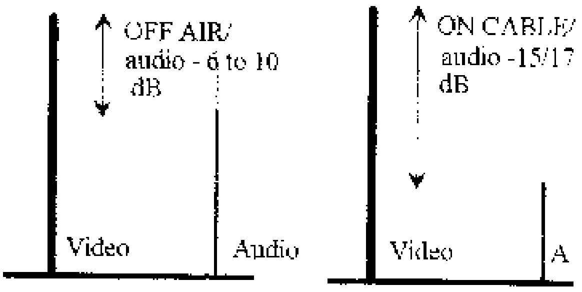
Unfortunately, the local environment at or near a particular cable amplifier (exhausts from a chimney, the blast from an air conditioner vent on a building below) often told an amplifier temperature sensor to do something it should not do.

Today the trunk amplifiers typically use a built-in *RF sensing* system. The system operator places a full-time programming service (i.e., one that operates 24 hours per day) on two channels; one at the low end of the spectrum (such as channel 2 or 3) and another at the high end (such as channel 9, 10 or 11). These might be satellite fed services, a local automated weather channel, or a community announcement service. Then every third or fourth trunk amplifier is equipped with an RF sensor; a pair of tuned circuits that constantly monitor the signal level at the input to that amplifier for both of the two selected channels. If there is a variation in the low band signal but none in the high band signal, the sensor system activates an AGC that functions to raise by a calculated amount the gain of the amplifier on low band. And so on ... by compensating for changes every third or fourth amplifier the system becomes stable to its original (typically) +/- 0.5 dB standard.

Headend And Consumer Levels

TV1 and TV2 transmitters typically operate such that their video and audio power levels (as radiated into the ether) are around 6-10 dB apart; the video being the strongest. A modern television set will produce perfectly acceptable sound reproduction when the audio carrier signal is from 15 to 17 dB lower in level than the companion video carrier level; a much greater carrier level difference than found 'off-air.'

When you are stacking channels in adjacent configuration (i.e., on the cable, 2 and 3 are adjacent in frequency; 4 is adjacent to 5 which is adjacent to 6 which is adjacent to 7 .... to 11), you must consider the capabilities of the standard consumer TV set. Most older, some newer sets have a great deal of difficulty dealing with an adjacent channel signal even if both are of the same signal strength (as in theory all of the adjacent cable channels should be at the consumer set; within 0.5 dB). Cable operators



-IMPROVING ON-CABLE ADJACENT CHANNEL OPERATION-learned decades ago that you can help the TV set do a better job if you reduce the audio carrier level on the cable plant from the 6-10 dB difference off air to as a minimum 15 dB and better yet 17 dB. This will make a considerable improvement in the ability of consumer TV sets to tune in channel 7, for example, without having hash marks in the picture from the channel 6 sound. It will also save the consumer a service call to have their older TV set IF sound traps re-tweeked since over time they have undoubtedly slid a ways away from their original factory settings.

These adjustments are made at the cable headend by simply monitoring the audio carrier level in the headend channel processor or modulator for each channel, having first determined the test point level of the same channel visual carrier level, and turning down the audio carrier level control until your signal level meter says you are -15/-17 from the video carrier. Once set, the cable plant will carry the signal throughout just as you set it at the headend.

Many cable systems in rural areas find that cable sells better if it also offers improved quality FM band reception. Since our TV channels do not conflict with our FM channelling (89-100 MHz at present), you can install headend FM 'levelling' equipment and with a broadband antenna and broadband FM amplifier place the entire FM band on your cable just as if it were another TV channel. Fortunately, the FM receivers that you will connect to your system require very little signal RF voltage to function properly; far less signal voltage than the 0 dBmV to +12 dBmV the TV sets require. In fact, if you turn your FM amplifier at the headend down to the point where the strongest FM signal is no stronger on your signal level meter than your channel 3 cable TV sound carrier, you will find the FM receivers connected will perform flawlessly. This means the entire FM band, even 25-30 stations, can be added to the cable with a relatively minor increase in equipment and with no adverse impact on the cable plant design. Some cable systems charge an extra few dollars per month for the FM service; a few businesses will subscribe to FM but not wish the TV portion, for background music purposes in their shoppes or offices. The plant amplifiers pass 89-100 MHz anyhow; you might as well use it!

If in the home the TV receiver wants to see no less than 0 dBmV (1,000 microvolts) and no more than +12 dBmV, any home with two or more outlets, or a motel or other multiple outlet system will require a bit of sub-engineering.

Let's assume for the moment that a home requires four outlets and it is located along a feeder line where because of the RF signal voltage on the feeder at that point you would normally select a directional coupler with 20 dB of isolation (i.e., the drop signal level would be -20 dB reference the feeder line level). To save money, you would first consider a single drop wire into the home. But a 20 dB DT selected to produce say +3 dBmV at the end of 30 metres of RG-6/U drop cable would have to be split in a four way splitter; net result, the actual level at each of the four splitter outputs will be closer to -4 dBmV (the splitter having 7 dB of split loss). Here are the solutions:

a) Change the feeder line DT from a 20 dB isolation value to a 12 dB isolation value. The DT's have snap or screw in plates and you can change it without undoing the bulky feeder line 1/2 inch coax connectors or disturbing the DC powering on the line.

By reducing the -20 dB isolation DT to a -12 dB DT, we gain 8 dB; and now the output at each splitter port is +4 dBmV. If some of the line runs from the splitter to the far end of the house add too much attenuation, go down another step to a -10 or even -8 dB isolation tap.

b) Install a small customer premise 230vac power amplifier. Treat this as you would an off-air TV antenna installation and select a 10-12 dB gain broadbanded solid state amplifier to go at the end of your drop line, ahead of the splitter (or select a small amplifier with a built-in four-way splitter).

Don't even consider trying to power this sub-amplifier from your own plant AC supply; the problems are not very pretty.

c) Leave the 20 dB isolation tap in place and run four separate lines to the home's four separate sets. This is a less-than-best way but sometimes the quickest and least troublesome.

A motel with 30 TV sets? If it already has some type of distribution system your first concern is whether the active (amplifier) portion already installed is capable of handling your 11 TV channels plus your FM station channels. Possibly not, in which case you bid an amplifier change out as a part of the installation deal. Many amplifiers are rated to handle four (for example) channels at a rated output level. And 11 channels will cause it to overload and cross-modulate.

If the motel has no internal distribution system. design one as a separate project and sell it with the installation. Should you actually sell the motel the system or should you wheel and deal with them on the per room rate per night/month? That's a business decision beyond the scope of this report. You could retain ownership of the motel subsystem yourself, charge more per room per month and come out ahead, swallowing the cost of the system now for a larger pay back later.

Channelling

Although New Zealand has 11 VHF channels assigned to television, and modern (mostly Asian made) TV sets/VCRs have tuners in them typically capable of handling 30 pre-set memory channels, you may for a wide range of reasons ultimately wish to make use of TV channelling which is outside of the 11 VHF channels. Consider:

a) Channel 1 is 44-51 MHz and should be cable-avoided in the interest of being able to select CATV plant amplifiers which are readily available but (only) cover 50/54 MHz upwards. They do not work at 44/45/46 etc. MHz and for this reason you will probably have to give up on channel 1 when you build your system.

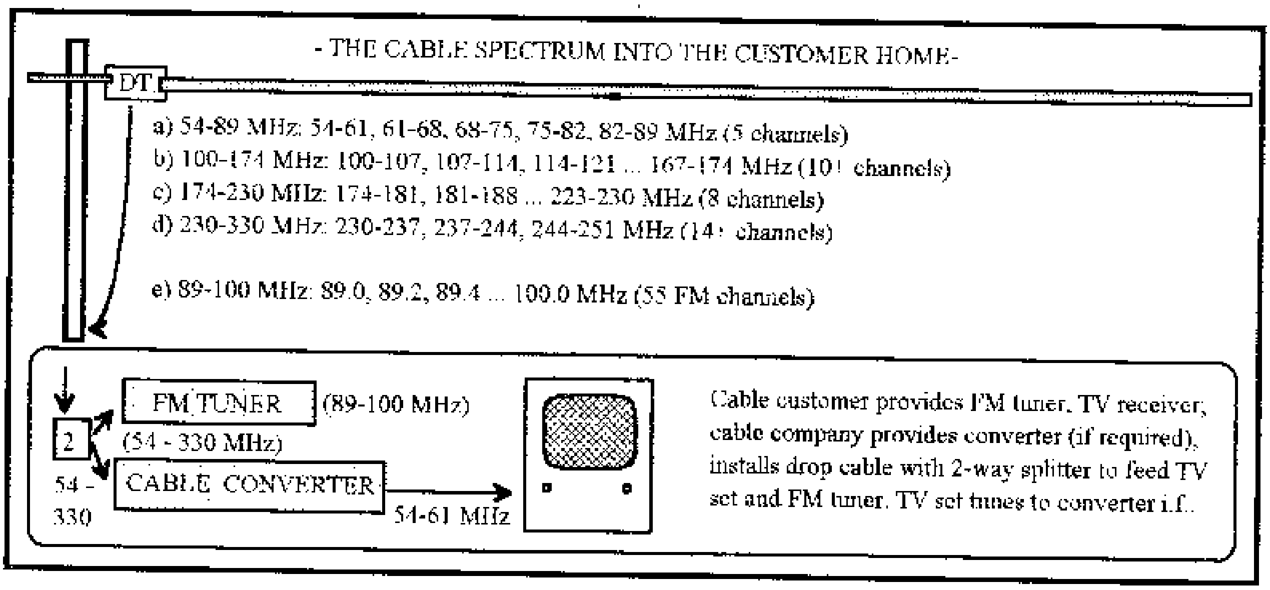
If there is a channel 1 you wish to carry on your system coming off air on channel 1, simply move it with your headend equipment to some other channel; such as 2.

b) Channels 2 and 3 are continuous from 54 MHz to 68 MHz.

c) The FM band occupies 89 to 100 MHz.

d) Channels 4 to 11 are continuous from 174 MHz to 230 MHz.

If your CATV plant amplifiers are designed to cover 50/54 to 330 MHz, you have the



- THE CABLE SPECTRUM INTO THE CUSTOMER HOME-

a) 54-89 MHz: 54-61, 61-68, 68-75, 75-82, 82-89 MHz (5 channels)
b) 100-174 MHz: 100-107, 107-114, 114-121 ... 167-174 MHz (10+ channels)
c) 174-230 MHz: 174-181, 181-188 ... 223-230 MHz (8 channels)
d) 230-330 MHz: 230-237, 237-244, 244-251 MHz (14+ channels)

e) 89-100 MHz: 89.0, 89.2, 89.4 ... 100.0 MHz (55 FM channels)

Cable customer provides FM tuner. TV receiver; cable company provides converter (if required), installs drop cable with 2-way splitter to feed TV set and FM tuner. TV set tunes to converter i.f..

following spectrum which you will not use if you stick to the standard channels 2 to 11:

a) 68-89 MHz
b) 100 to 174 MHz
c) 230 to 330 MHz.

Even if you do not place TV channels in these regions, the CATV plant will amplify these spectrums. So, what is to stop you from assigning cable TV channels to one or all of these regions? The answer is only the ability of your customer's TV receivers to tune in these non-standard frequencies is a factor.

Many of the Asian built tuners (by Alps and Matsushita for example) continuously tune from 44 to well over 300 MHz. They are made to sell world wide and they don't know or care where they are in the world when they move through the VHF spectrum looking for channels to lock on and memorise.

For customers with these TV tuners, where you place your channels between 54 and 330 MHz is of no importance. And for the customers who still have the old, original four or six channel position sets? They will require a 'cable converter' anyhow and those sets manufactured before there was a channel 11 will also not get all of your channels. Into this group of homes you offer to lease/rent a cable company channel converter; one of the NZ$90 units that you will find available from the same sources as your plant amplifier equipment.

So there is really nothing to stop you from creating your own channelling scheme, using the region between 54 and 330 MHz, to establish your community 'TV venue.' This is your 'growth room' and as many brand new satellite delivered services become available to you, with the addition of a single new TV channel modulator you will be able to add a new channel in just a few minutes time. By building the plant with 330 or even 550 MHz bandwidth, you are providing yourself with plenty of future growth room.

Those three frequency blocks not in use for TV or FM, by the way, will provide:

a) 68-89 MHz - 3 x 7 MHz analogue
b) 100-174 MHz - 10+ x 7 MHz analogue
c) 230-330 MHz - 14+ x 7 MHz analogue

With room for 10 standard VHF and 27 special VHF channels each 7 MHz wide, you won't be running out of space very soon!

Locating The Equipment

Cable TV equipment is neither stocked, manufactured nor represented in New Zealand at this time, with one exception. A limited amount of CATV 'grade' equipment from Japanese suppliers is available in the headend electronics area.

"*But*" you point out, "*I have a catalogue from a Japanese supplier* (such as Maspro) *and it lists 'CATV Equipment'*?" Let's clear that one up.

Japanese 'CATV' is unique to Japan. There are more than 30,000 such systems there according to their Communications Ministry. The average 'length' of a Japanese cable plant is under 5 kilometres of cable; many are less than 1 kilometre. These are in truth 'SMATV' or satellite master antenna TV systems. They differ from cable primarily because the active plant electronics they require is of the feeder line design family, not trunk lines. This means their amplifiers are not designed for long cascades (in this case even four amplifiers in a row, which exceeds their capabilities, would be considered a 'long cascade') but rather for short runs. The typical Japanese cable system feeds homes, apartments or buildings within a single 'block', seldom carries its service across a public street to another block, and combines off-air satellite signals with off-air VHF/UHF signals more as a master antenna than as a 'community wide' system.

On the other hand, some of the Japanese designed headend equipment is quite satisfactory, especially in the satellite area and for smaller systems their passive devices (splitters, directional couplers) are adequate if expensive.

A recent study suggested that 75% of all cable television equipment is manufactured in the US, or sold by companies that headquarter there (some, like everything else electronic, is assembled in Asian countries and shipped back to the US). Europe accounts for the bulk of the remainder with Germany and the Scandinavian countries volume producers.

However, even many of the German firm catalogues label 'SMATV' plant equipment as 'CATV' and it would be a big mistake to plan a cable plant around the wrong category of electronics. If in doubt, ask somebody that knows.

There are four primary categories of materials in the CATV plant; the headend is another master category. They are:

1) The cable itself, including the trunk, feeder and drop versions

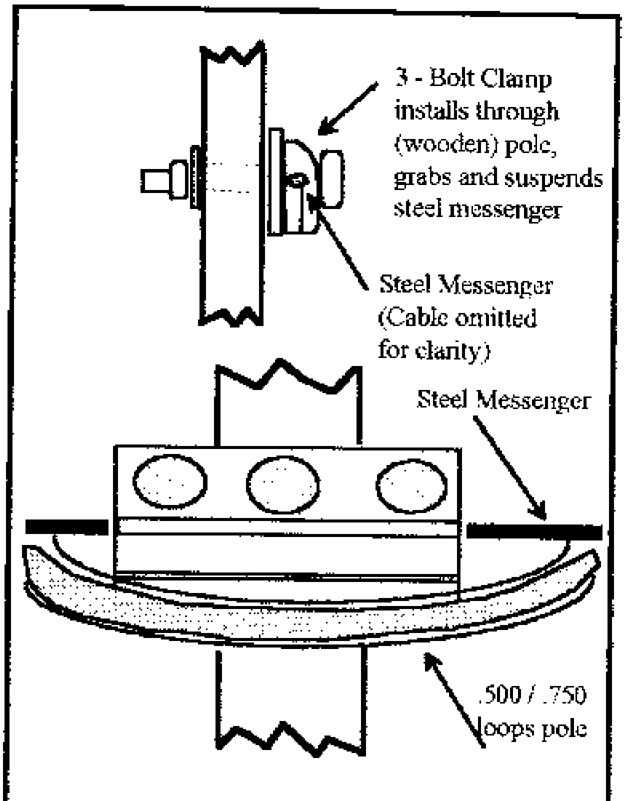
2) The active (amplifying) electronics

3) The passive (signal splitting, conditioning) electronics

4) The hardware required to install/connect the cable/electronics to either utility poles, your own poles, or to place the cable underground.

In the cable area, other than some basic drop cables (principally RG-59/U) no New Zealand manufacturer makes product here. Drop cables require very high shielding percentages, by the way, because of the relatively high drop signal levels and the susceptibility of the drop to ingress of local noise/RF sources that can enter an improperly shielded cable. Anything less than 90% shielding, or alternately 60% braid shield combined with a 100% foil shield, is inadequate. Drop cables must also be of the 'foam' (lower loss) family. Trunk, feeder and drop cables are available in a variety of formats:

1) Plain cable, with or without (in the case of trunk and feeder) a poly jacket (the black coloured protective guard previously described),


3 - Bolt Clamp installs through (wooden) pole, grabs and suspends steel messenger
Steel Messenger (Cable omitted for clarity)
Steel Messenger
.500 / .750 loops pole

-TYPICAL POLE LINE HARDWARE-

2) Cable with integrated messenger; trunk, feeder and even drop cables lack the ability to 'support themselves' over long 'spans' (i.e., while hung in the air between two solid suspension points). A short span of up to 15 metres for a drop cable may be unsupported; longer runs plus all runs of trunk and feeder cable require some type of supporting wire. This is called the messenger, and it is basically a steel wire of sufficient strength to support the weight of the cable in question while suspended.

Drop, feeder and trunk cables with the messenger included in the configuration is called 'integrated messenger cable' (or 'figure 8'). With integrated messenger the construction process involves unrolling the single piece/dual purpose cable from the roll between two points (such as two poles), lifting the cable to the correct height at both points of suspension, attaching one end under strain pressure (using hardware that attaches to the pole and the steel strand portion of the cable), and then raising the opposite end to the proper height and tensioning the span to the correct 'droop' or depth before attaching it as well. It sounds far more complicated than it is, and special tools and

-CABLE LIST PRICING FROM PROMINENT US SUPPLIER-

PRICING / SELECTED CATV CABLES

Trunk/Feeder:

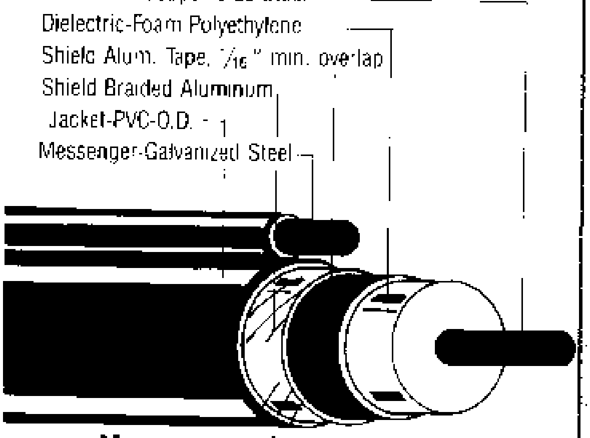
1/2" / .500:

1) Bare: NZ$477 per 305 metres
2) Jacketed Aerial: NZ$570 per '305m'
3) Integral Messenger: NZ$735 per '305m'

3/4" / .750:

1) Bare: NZ$949 per '305m'
2) Jacketed Aerial: NZ$1034 per '305m'
3) Integral Messenger: NZ$2523 per '305m'

RG59/95% braid/messenger: $142 per '305m'
RG6/90% braid/messenger: $159 per '305m'


Conductor-Copper Clad Steel
Dielectric-Foam Polyethylene
Shield Alum. Tape, 1/16" min. overlap
Shield Braided Aluminum
Jacket-PVC-O.D.
Messenger-Galvanized Steel

Messenger equipped drop cables

than the first cut quotation you might obtain locally.

In the hardware area, most was originally designed for aerial installation of telephone trunk and distribution cables. Pieces vary with function, are almost always cast steel galvanized for long term protection, and are chosen for their particular function. In the case of wooden poles, holes drilled through the poles accept properly sized bolts that firmly attach the hardware to the poles. Square washers, spacers and clamps designed to catch and hold onto the steel strand are the basic building blocks. For concrete poles, stainless steel straps that wrap around the pole and tension secure the hardware (often called 'three bolt clamps' in the trade) to the pole. The object with all of the hardware is to have a very long term life, to simplify the installation process, and to keep costs down. Some of this will already be available in New Zealand but with the undergrounding of most telephone lines, prices will be far lower overseas where this sort of hardware is still available in huge quantities.

The active and passive electronics presents the Kiwi cable TV system builder with a unique opportunity. Used, re-conditioned equipment is the reason.

For 25% (or less) of the cost of new 330/450/550 MHz trunk and feeder amplifiers you can find an almost endless supply of ten or even five year old 'name brand' (Jerrold, Scientific Atlanta, Magnavox et al) equipment through USA firms. We list several here in a

-SUPPLIERS OF RE-CONDITIONED CABLE PLANT EQUIPMENT-

1) Main Line Equipment Inc. / Los Angeles FAX: 001-310-715-6695 (Sy Sasmor)
2) PTL Cable Service, Inc./ Jupiter, FL FAX: 001-407-747-3647 (Paul T. Legris)
3) Arena Services, Inc. / Jeffersonville, Pa. FAX: 001-215-630-8202 (Wayne T. Arena)
4) Coast CATV Supply / FAX: 001-909-272-3032
5) dB-tronics / Wellford, SC FAX: 001-803-439-7518
6) C PRO Inc. / Independence, Mo. FAX: 001-816-254-5782

Name-brand 330 MHz trunk stations vary from NZ$555 to $830; 450 MHz trunks in $850 region. Line extenders vary from NZ$160 to $280. These units, typically with 6 to 12 month warranty, are at prices from 40-60% of new units.

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As American and Canadian CATV plants have grown in bandwidth over the past decade, cable system operators have been forced to remove from service lesser bandwidth equipment and 'trade it in' for the newer wider band equipment. Recall that virtually any unit manufactured after approximately 1975 has all of the basic refinements of automatic level control, solid state reliability, well debugged electronics as found in the current lines of equipment. This becomes a major cost-saving opportunity when designing and building a new cable system here.

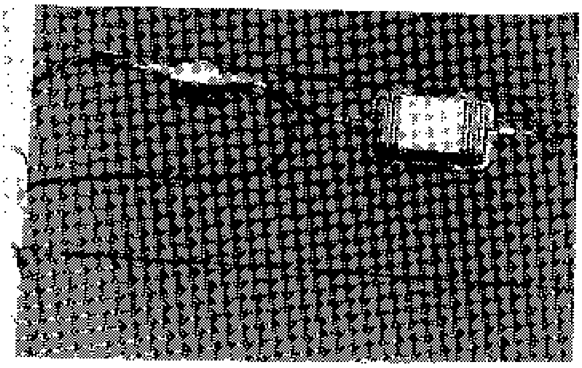
But you will need to understand the individual parameters/specifications of the various model numbers and brands to comprehend the usually abbreviated 'Reconditioned Equipment List' catalogues. The sellers, many of whom offer substantial warranties or guarantees on the equipment serviceability, make the assumption that would be buyers are already aware that a specific Jerrold amplifier has certain characteristics. 'Out of the loop' as we are here, lacking the decades of experience which the US and Canadian buyers already have, Jerrold part numbers mean little to us.

The best solution to this problem is to have a clear focus on the type of amplifier/plant specifications you will require. For example, suppose you have determined you want:

1) A 330 MHz CATV 'plant' with trunk amplifiers capable of:

a) -36 dBmV output
b) plug-in equalisers for tilt adjustments
c) operating over a range of 22 to 60 vac
d) a forward direction spectrum of 54 to 330 MHz
e) a reverse direction spectrum 'capability' of 5-35 MHz
f) a maximum noise figure of 10 dB.
g) power supply to operate with 50 hertz source
h) RF sensing trunk amp AGC modules

-RURAL CABLE PLANT-



AMP (right) feeds splitter (left)

By citing these specifications to a would be supplier, he in turn can suggest which equipment will do this job, and quote you pricing accordingly. There is no particular risk to mixing (for example) Jerrold and Scientific Atlanta amplifiers in the same plant as long as both have similar specifications, and you have adequate 'spares' in your inventory for either.

Plant amplifier housings (trunk or feeder) are designed to mount permanently (typically at a pole so you can get to and work on a unit) and if there is a service problem, you open the housing and remove either the RF or power supply board, replacing it in place with a new board. The housings almost never require change-out

Similarly, plant splitters, trunk or feeder directional couplers often employ a 'universal housing' (one set of mechanical specifications) and the bottom plate pops out for replacement of the electronics proper. It must be noted that passives such as splitters and couplers have frequency limitations just like the active units; splitters or couplers 'good to 330 MHz' (or 550 MHz) are just that. So as the (US) plants

-DT/DIRECTIONAL TAPS-

'Isolation value' (i.e., -11) stamped on unit

upgraded from 330 MHz to 550 MHz, typically they pulled out the passives along with the active equipment.

The one piece of plant equipment you are most likely to buy 'new' is the customer directional coupler/directional tap. The DT units are priced so reasonably that it makes less sense to save 50% on them by buying used gear. Like the rest of the passives, their universal housings allow you to exchange the electronics by replacing a bottom plate that contains the tap off electronics. Taps are available with 1,2,4,8 and 16 outlets. The 1, 2 and 4 outlet taps fit into a single strand mounting housing; the 8 and 16 outlet taps usually require a larger housing. As a practical matter, the pricing differential between a 1 outlet DT and a 4 outlet DT is so small that you will probably elect to install 2 or 4 outlet units even where it seems like only one customer can be reached from that DT.

(When the cable plant is designed, every foreseeable DT is placed on the map in advance and when the plant is built all of the DTs are installed. Why? Because the DTs have a measurable amount of thru-put loss or attenuation which they contribute to the feeder line. It would be a nightmare to have to go out and cut the feeder cable (hot with 30/60vac) to install a DT 'housing' for each new subscriber as they sign up; and to then back track to make amplifier adjustments to accommodate the new thru-put loss on that line because of the newly installed DT. Thus the cable plant is designed and built as if every DT that might be required is going to be used by a customer from day one. This simplifies the actual customer hook-up process since the installer will find a DT properly situated to serve any home that might subscribe.)

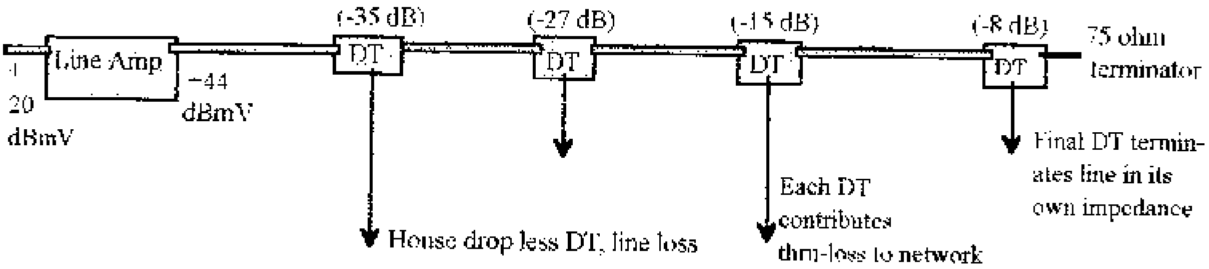
Finally, power supplies (providing 30/60vac to the cable electronics) will require new product. US and Canadian units typically have AC inputs of 120 volts and 60 hertz; not directly usable here.

Unusual Amplifiers

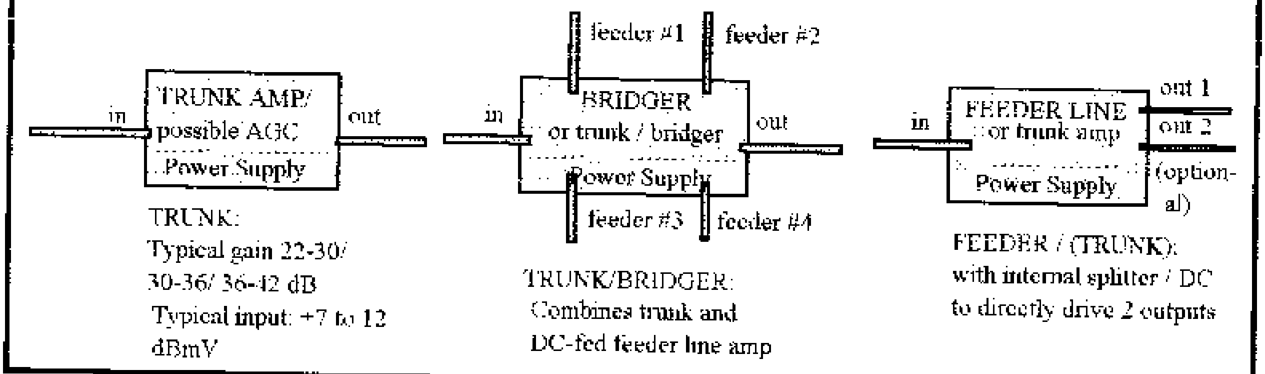
Variations in the standard 'one input/one output' feeder and trunk amplifiers exist. For example, some have built-in two way splitters at the output, or directional couplers; eliminating the need for a separate passive device. Others perform trunk to feeder cable connections and are called 'bridgers.'

The trunk amplifier amplifies the trunk signal. But when you wish to feed into a feeder line, it may be design-convenient to start the feeder line at the output of a trunk amplifier. This could be done with a two-way splitter or

-FEEDER CABLE LOSS, EACH DT THRU LOSS REDUCES LINE LEVEL-


+20 dBmV
Line Amp
-44 dBmV
(-35 dB)
DT
(-27 dB)
DT
(-15 dB)
DT
(-8 dB)
DT
75 ohm terminator
House drop less DT, line loss
Each DT contributes thru-loss to network
Final DT terminates line in its own impedance

-TYPICAL AMPLIFIER CONFIGURATIONS-



directional coupler (where one output feeds the trunk, the second the feeder), or, it could be done with a 'bridger amplifier.' Bridging means just what it sounds like; a link between the trunk and the feeder(s). Because it may be convenient from a design stand point to place a trunk at an intersection where as many as four separate feeders will originate, there are trunk/bridger amplifiers that (a) perform the trunk amplification, and , (b) provide as many as four separate feeder line outputs to drive feeder lines going down four separate streets. Inside of a trunk/bridger is a directional coupler that taps off a medium level amount of signal from within the trunk amplifier which in turn feeds into a 'bridger amplifier' that has (in our example) four separate, isolated outputs.

Feed Back/Return Loop

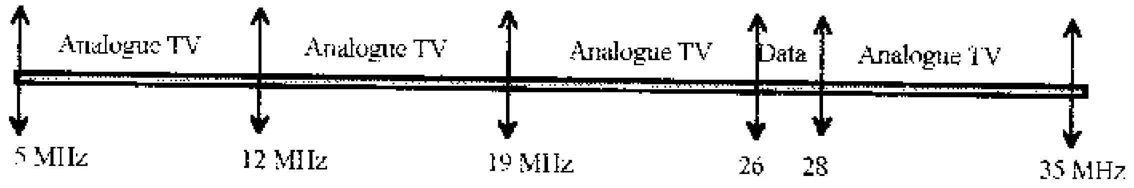
Because most cable systems begin their forward direction bandpass window between 50 and 54 MHz (some European equipment begins at 47 MHz; no equipment begins at 44/45 MHz for either New Zealand or Australia) and goes upward to the design limits of the amplifiers, this leaves (on purpose) a region below 50 MHz for a 'return band loop.' High pass and low pass filters are included in all trunk amplifiers to define the forward and return portions; the region between approximately 35 and 50 MHz is where the respective filters 'cross' and is not useful for either direction. The return band is typically defined as 5 to 35 MHz.

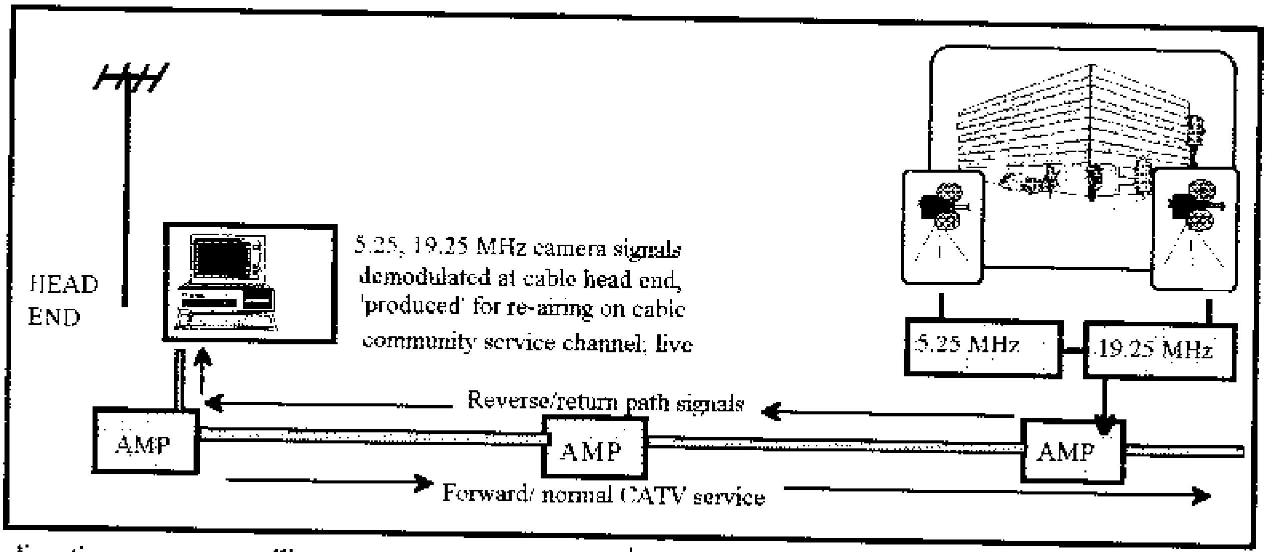
At such a low frequency, cable losses are very low and whereas you might require a forward direction (50-330 MHz) amplifier every 400 metres of cable, the return band could get by with a new amp every 2,000 metres of cable.

Trunk amplifiers are often equipped with a set of slide-in connectors such that equipment can be added to any trunk amplifier station to pass the 5-35 MHz return band through the amplifier. Now the output becomes the input, the input the output because signals sent in this

-RETURN BAND SPECTRUM(*)-

* - Cable operator determines




HEAD END
5.25, 19.25 MHz camera signals demodulated at cable head end, 'produced' for re-airing on cable community service channel; live
5.25 MHz
19.25 MHz
Reverse/return path signals
AMP
AMP
AMP
Forward/ normal CATV service

direction are travelling to, not from, the headend.

Kiwi Cable uses this frequency spectrum when covering local council meetings and other local events; by tying one camera to a 5-12 MHz modulator, a second camera to a 19-26 MHz modulator at the council chambers, two separate camera shots can be sent in real time using return band back to the cable studio. There a director selects a shot from the two available, adds captioning (names) if required, and sends the now edited programme back out on cable in the forward direction on a channel set aside for this purpose. The beauty of this is that the cable company is totally self-sufficient to provide live coverage of events in the community; all it requires is access to a trunk amplifier station where it can inject the return band originating video and audio into the trunk for the return path to the cable headend.

Trunk (and some feeder, but not all feeder) amplifiers equipped with 'return band capability' have the necessary in-housing slots and filters in place to allow use of that housing for the return band. To activate the return band 'option', the cable operator adds electronics at each trunk 'station' between the site of his remote pickup and the headend.

Because of low cable losses in the 5-35 MHz spectrum, he may need no active 5-35 MHz amplifiers at all; the 5-12 MHz TV modulator, for example, is perfectly capable of supplying sufficient output to reach all the way back to the headend without additional re-amplification. In this case 'patch boards' that activate or tie together the individual amplifier housing input/output ports are installed; a simple task of opening the amplifier housing and sliding a pre-wired path board into the slots. If Kiwi Cable did require an amplifier (the calculations are identical to the forward path; so many metres of cable equals so many dB of loss at the operating frequency), the slot at the appropriate amplifier 'station' is filled with a small solid state amplifier board. Powering and filtering is already in place from the forward direction trunk electronics in the same housing.

The 5 to 35 MHz spectrum is useful for many other purposes as well. In some advanced two-way cable systems each cable set-top converter/translator is equipped with a small 'transmitter' operating on an assigned frequency in the 5-35 MHz region. This allows the cable company to accept instructions or orders from the cable customer through its own plant; independent of the local telephone company. MOND and MOD are handled in this way with some systems. When the time comes for you to implement this technology, you'll take the time to learn about it.

Initially, it is quite foolish not to source trunk amplifiers that have return band (5-35 MHz) capability since the additional cost is seldom greater than 10 percent and often as little as 5%. With these return band capable amplifiers in place, your system is ready for some future two-way application without an overhaul.

System Layout Assistance

Virtually all major manufacturers of original equipment (i.e., plant electronics) will take your basic information and create a suggested plant layout/design. Jerrold, for example, maintains an office in Singapore from which their layout and engineering department does system planning. Typically, if you take their layout and ultimately purchase their equipment, there is no surcharge for this service (although you can be certain their costs for the layout are somehow buried within the equipment pricing). On the other hand, if you are simply looking for a 'free' layout of your system, you will usually be charged. Rates run to $100 per kilometre of layout after you provide accurate, scaled maps of the community with the utility routings and homes clearly marked.

The headend requires similar planning since the skills required to create and mix multiple channels of processed television, selecting the most cost effective equipment in the process, are considerable. Again, suppliers such as Blonder Tongue will do the layouts for you but if you want a layout and don't buy the equipment, expect to be charged. A fee of $100 per channel plus $500 is not unusual.

What you get back after either of these exercises is a complete plan for a cable system; every piece of passive and electronics is specified by brand and model number, their exact location and cabling connections shown for your town, your streets. Some will also supply a BOM (bill of materials).

Computer programmes to layout CATV plants (and with some difficulty, headends) exist. But the software of the quality programmes costs upwards of $4,000 so you had better plan to use it more than once and then prepare yourself for intensive self-teaching as to the knowledge required to input the raw data. The University of Pennsylvania (among others) offers a four year engineering course in cable TV system design so it is not something one does on a piece of butcher wrapping paper or a brown shopping bag anymore.

Update on Kiwi Cable Status

Since our December (issue 9305) report, Broadcast Communications Limited (BCL) has begun work on a Whitby area (Wellington) traditional cable TV system. Wellington's irregular terrain creates many pockets where TV reception is difficult or impossible; there are more than 30 TV translator channels serving the city area. Whitby section has been especially difficult to service and BCL is entering the cable TV business by building a 550 MHz bandwidth cable system to initially service around 100 homes that are denied quality TV reception. BCL will use Jerrold line amplifiers and Phasecom (an Israeli firm) headend equipment. Additional areas in Wellington and elsewhere are under BCL study.

In Greymouth, planned cable TV system PacSat is still just that; not-operational other than some limited testing. PacSat had hoped to provide TV3 via a Hokitika channel 11 translator installed just prior to Christmas but that did not work out (see Coop's Technology Digest 9401: January 1994). The Greymouth installation would not serve as a 'model' for most other Kiwi cable systems as it is ignoring thirty years of hard learned technology do's and don'ts by treating every 'block sized area' as if it were a separate mini-cable system. They plan to integrate each block with the headend through a unique use of 12,000 MHz microwave. So far PacSat has refused to obtain a pole attachment agreement with the local power utility and their cables have been tacked on fences, corner's of buildings and laid on the ground. It is a very strange way indeed to build a permanent business and its example is mostly illustrative of what can happen if you ignore every textbook ever written in this field.

TECHNICAL REPRINT SERVICE

TECHNICAL PAPERS created over the period 1956 to present, by Tech Bulletin editor Robert B. Cooper, trace the development of television (terrestrial and satellite) from the early black and white 'days' to the modern GaAs-FET low noise amplifiers. Reprint/copies of selected reports are available from files. Use this form, or copy; include your name and address for prompt service!

ANTENNAS

LaPORTE and other Rhombics; 15 pages. Fully describes use of single, multiple (stacked) Rhombic antennas in VHF (UHF) range for terrestrial (horizon-angle) reception with directivity and gain combinations unmatched by any other antenna design.

☐ **LaPorte RHOMBIC Construction / $10**. (reprint 10/76)

HALF-BOLICS; 25 pages. Full description of theory and duplication of broad band (bands I,III,IV and V) beyond-horizon screen reflector plus feed system capable of quality reception to distances of 250km.

☐ **HALF-BOLICS Construction / $15** (reprint 123/78)

SURFACE WAVE Logis; 9 pages. Oliver Swan 'invented' log-periodic antennas. At the time of his death he shared notes on a new 'surface wave' design of 18 dB gain yagi-log hybrids. Complete build-your-own details; 50-230 MHz

☐ **SURFACE WAVE LOGIS Construction/ $10.** (reprint 3/77)

G-LINE TRANSMISSION Systems; 7 pages. A single-wire transmission line with losses under 1 dB per 100m at 500 MHz. Lowest possible loss of any known transmission line; construction details.

☐ **G LINE SYSTEMS/ $10**. (reprint 23/62)

MEASUREMENTS/MEASUREMENT SYSTEMS

EVERYMAN'S ECONOMY SPECTRUM ANALYZER; 12 pages. Take a varactor tuned $80 CATV converter, add some clever circuits and demodulate the output in a scope detector feeding into your low-cost scope. Result? A spectrum analyzer covering 40-300 MHz (+). Brilliant test equipment on a budget.

☐ **EVERYMAN'S ANALYZER/ $10**. (reprint 711/75)

MARKER GENERATOR/MARK-A-CHANNEL; 25 pages. Although USA channelized, adaptable to NZ TV channels. A pair of low-cost ways to construct your own scope-display (or FSM) channel-marker for alignment and test.

☐ **MARKING TV CHANNELS/ $15**. (reprint 578/74)

FIELD STRENGTH/SIGNAL LEVEL METERS, How They Work; 80 pages. Comprehensive overview of how VHF/UHF TV signal strengths are translated to meaningful 'numbers', with analysis of commercial products in field.

☐ **FIELD STRENGTH METERS/ $35**. (reprint 10112/74-156/75)

CABLE MATCHING / VSWR MEASUREMENTS; 5 pages. When 75 ohm cable is connected to a mismatched source or load, signal voltage is lost. Now you can measure match, and with the described 'matchbox' correct for mismatch.

☐ **CABLE MATCH / MATCHBOX/ $5.** (reprint 1175/3/76)

SELF-HELP CONSTRUCTION PROJECTS

SIMPLE TV PASS BAND FILTERS; 15 pages. An extensive review of how (single/multiple channel) bandpass filters for TV are designed plus a series of bench-build filters you can create. Isolate single channels, cleanly!

☐ **TV PASS BAND FILTERS: Construction/ $10**. (reprint 12/74-3/76)

THE GAIN BLOCK; 14 pages. Take either of two broadband chips (TRW 501; HP35600B) and with instructions create either of two broadband (20-300 MHz+) bench amps (16 to 30 dB gain) with 75 ohm input/output impedance.

☐ **THE GAIN BLOCK; Construction/ $15**. (reprint KIT-2/78)

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